# BIHAR AGRICULTURAL COLLEGE, SABOUR
# DEPARTMENT OF BIOCHEMISTRY & CROP PHYSIOLOGY


# COURSE NO. ABP-211 (2+1)
# COURSE TITLE: ENVIRONMENTAL STUDIES & DISASTER MANAGEMENT

**By**

**SAREETA NAHAKPAM/ A K PAL/ R D RANJAN/ M P MANDAL**

**Lecture No. : 01**

## Concept of Environment

The environment is defined as that whole outer physical and biological system in which man and other organisms live. It is a complicated one with many interacting components. The term environment etymologically means surroundings. Thus the environment is a complex of so many things (light, temperature, soil, water etc.) which surround an organism. Any external condition, substance or force which surrounds and affects an organism is called a factor and all such factors taken together may be called as environment. These factors have been variously called as environmental factors or ecological factors or simply factors. These factors may be biotic (living) as well as abiotic (non-living). The place where an organism lives is called habitat which presents a particular set of environmental conditions- the environmental complex.

According of Oosting (1948) the environment is a complex of variable factors or causes. This includes substances (soil, water), conditions (temperature, light) and forces (wind, gravity), organisms (plants, animals), time.

Life does not occur in a vacuum. Every living organism is surrounded by materials and forces which constitutes its environment. From this the organism derives its needs.

The early growth of environmental knowledge id intimately related with evolutionary and cultural development of man. Early man was preagricultural, hunter and food gatherer. He survived in a rich and competitive biotic community and his relationship to his community was continually intimate. The prehistoric man used environmental information in hunting, fishing, traping animals, locating and gathering edible vegetation. An increased knowledge of the importance of environmental conditions led to religious rituals, myths, worship of weather gods etc. The establishment of agricultural cultivation increased the need to learn about practical knowledge of environment, domestication of plants and animals which altered the entire pattern of human existence.

## Environmental Science: Scope and importance

The science of Environment studies is a multi-disciplinary science as it comprises various branches of studies like chemistry, physics, medical science, life science, agriculture, public health, sanitary engineering etc. It is the science of physical phenomena in the environment. It studies of the sources, reactions, transport, effect and fate of physical a biological species in the air, water and soil and the effect of from human activity upon these.

Literary environment means the surrounding external conditions influencing development or growth of people, animal or plants; living or working conditions etc. This involves three questions:

1. What is Surrounded

The answer to this question is living objects in general and man in particular.

2. By what Surrounded

The physical attributes are the answer to this question, which become environment. In fact, the concern of all education is the environment of man. However, man cannot exist or be understood in isolation from the other forms of life and from plant life. Hence, environment refers to the sum total of condition, which surround point in space and time. The scope of the term Environment has been changing and widening by the passage of time. In the primitive age, the environment consisted of only physical aspects of the planted earth' land, air and water as biological communities. As the time passed on man extended his environment through his social, economic and political functions.

3. Where Surrounded

The answer to this question. It is in nature that physical component of the plant earth, viz land, air, water etc., support and affect life in the biosphere. According to a Goudie environment is the representative of physical components of the earth where in man is an important factor affecting the environment.

**Scope of Environment:** The environment consists of four segments as under:

1. **Atmosphere:** The atmosphere implies the protective blanket of gases, surrounding the earth:

(*a*) It sustains life on the earth.

(*b*) It saves it from the hostile environment of outer space.

(*c*) It absorbs most of the cosmic rays from outer space and a major portion of the electromagnetic radiation from the sun.

(*d*) It transmits only here ultraviolet, visible, near infrared radiation (300 to 2500 nm) and radio waves. (0.14 to 40 m) while filtering out tissue-damaging ultraviolate waves below about 300 nm. The atmosphere is composed of nitrogen and oxygen. Besides, argon, carbon dioxide, and trace gases.

2. **Hydrosphere:** The Hydrosphere comprises all types of water resources oceans, seas, lakes, rivers, streams, reserviour, polar icecaps, glaciers, and ground water.

(*i*) Nature 97% of the earth's water supply is in the oceans,

(*ii*) About 2% of the water resources is locked in the polar icecaps and glaciers.

(*iii*)Only about 1% is available as fresh surface water-rivers, lakes streams, and ground water fit to be used for human consumption and other uses.

3. **Lithosphere:** Lithosphere is the outer mantle of the solid earth. It consists of minerals occurring in the earth's crusts and the soil *e.g.* minerals, organic matter, air and water.

4. **Biosphere:** Biosphere indicates the realm of living organisms and their interactions with environment, viz atmosphere, hydrosphere and lithosphere.

**Element of Environment**

Environment is constituted by the interacting systems of physical, biological and cultural elements inter-related in various ways, individually as well as collectively. These elements may be explained as under:

(1) Physical elements

Physical elements are as space, landforms, water bodies, climate soils, rocks and minerals. They determine the variable character of the human habitat, its opportunities as well as limitations.

(2) Biological elements

Biological elements such as plants, animals, microorganisms and men constitute the biosphere.

(3) Cultural elements

Cultural elements such as economic, social and political elements are essentially manmade features, which make cultural milieu.

**Importance of environmental studies**

Importance of Environment Studies: The environment studies enlighten us, about the importance of protection and conservation of our indiscriminate release of pollution into the environment. At present a great number of environment issues, have grown in size and complexity day by day, threatening the survival of mankind on earth. We study about these issues besides and effective suggestions in the Environment Studies. Environment studies have become significant for the following reasons:

1. Environment Issues Being of International Importance

It has been well recognised that environment issues like global warming and ozone depletion, acid rain, marine pollution and biodiversity are not merely national issues but are global issues and hence must be tackled with international efforts and cooperation.

2. Problems Cropped in The Wake of Development

Development, in its wake gave birth to Urbanization, Industrial Growth, Transportation Systems, Agriculture and Housing etc. However, it has become phased out in the developed world. The North, to cleanse their own environment has, fact fully, managed to move 'dirty' factories of South. When the West developed, it did so perhaps in ignorance of the environmental impact of its activities. Evidently such a path is neither practicable nor desirable, even if developing world follows that.

3. Explosively Increase in Pollution

World census reflects that one in every seven persons in this planted lives in India. Evidently with 16 per cent of the world's population and only 2.4 per cent of its land area, there is a heavy pressure on the natural resources including land. Agricultural experts have recognized soils health problems like deficiency of micronutrients and organic matter, soil salinity and damage of soil structure.

4. Need for An Alternative Solution

It is essential, specially for developing countries to find alternative paths to an alternative goal. We need a goal as under:

(1) A goal, which ultimately is the true goal of development an environmentally sound and sustainable development.

(2) A goal common to all citizens of our earth.

(3) A goal distant from the developing world in the manner it is from the over-consuming wasteful societies of the "developed" world.

5. Need To Save Humanity From Extinction

It is incumbent upon us to save the humanity from exinction. Consequent to our activities constricting the environment and depleting the biosphere, in the name of development.

6. Need For Wise Planning of Development

Our survival and sustenance depend. Resources withdraw, processing and use of the product have all to by synchronised with the ecological cycles in any plan of development our actions should be planned ecologically for the sustenance of the environment and development.

7. Misra's Report

Misra (1991) recognized four basic principles of ecology, as under:

(*i*) Holism

(*ii*) Ecosystem

(*iii*) Succession

(*iv*) Conversation.

Holism has been considered as the real base of ecology. In hierarchical levels at which interacting units of ecology are discussed, are as under: Individual<population<community<ecosystem<biome<biosphere.

Misra (1991) has recognised four basic requirements of environmental management as under:

(*i*) Impact of human activities on the environment,

(*ii*) Value system,

(*iii*) Plan and design for sustainable development,

(*iv*) Environment education.

Keeping in view the of goal of planning for environmentally sustainable development India contributed to the United Nations Conference on Environment and Development (UNCED), also referred to as "Earth Summit" held at Rio de Janciro, the Capital of Brazil, 3rd-14th June, 1992.

**NEED FOR PUBLIC AWARENESS**

It is essential to make the public aware of the formidable consequences of the Environmental Degradation, if not retorted and reformative measures undertaken, would result in the extinction of life. We are facing various environmental challenges. It is essential to get the country acquainted with these challenges so that their acts may be eco-friendly. Some of these challenges are as under:

**1. Growing Population**

A population of over thousands of millions is growing at 2.11 per cent every year. Over 17 million people are added each year. It puts considerable pressure on its natural resources and reduces the gains of development. Hence, the greatest challenge before us is to limit the population growth. Although population control does automatically lead to development, yet the development leads to a decrease in population growth rates. For this development of the women is essential.

**2. Poverty**

India has often been described a rich land with poor people. The poverty and environmental degradation have a nexus between them. The vast majority of our people are directly dependent on the nature resources of the country for their basic needs of food, fuel shelter and fodder. About 40% of our people are still below the poverty line. Environment degradation has adversely affected the poor who depend upon the resources of their immediate surroundings. Thus, the challenge of poverty and the challenge environment degradation are two facets of the same challenge. The population growth is essentially a function of poverty. Because, to the very poor, every child is an earner and helper and global concerns have little relevance for him.

**3. Agricultural Growth**

The people must be acquainted with the methods to sustain and increase agricultural growth with damaging the environment. High yielding varieties have caused soil salinity and damage to physical structure of soil.

**4. Need to Ground water**

It is essential of rationalizing the use of groundwater. Factors like community wastes, industrial effluents and chemical fertilizers and pesticides have polluted our surface water and affected quality of the groundwater. It is essential to restore the water quality of our rivers and other

water bodies as lakes are an important challenge. It so finding our suitable strategies for consecration of water, provision of safe drinking water and keeping water
bodies clean which are difficult challenges is essential.

**5. Development And Forests**

Forests serve catchments for the rivers. With increasing demand of water, plan to harness the mighty river through large irrigation projects were made. Certainly, these would submerge forests; displace local people, damage flora and fauna. As such, the dams on the river Narmada, Bhagirathi and elsewhere have become areas of political and scientific debate.

Forests in India have been shrinking for several centuries owing to pressures of agriculture and other uses. Vast areas that were once green, stand today as wastelands. These areas are to be brought back under vegetative cover. The tribal communities inhabiting forests respects the trees and birds and animal that gives them sustenance. We must recognise the role of these people in restoring and conserving forests. The modern knowledge and skills of the forest deptt. should be integrated with the traditional knowledge and experience of the local communities. The strategies for the joint management of forests should be evolved in a well planned way.

**6. Degradation of Land**

At present out of the total 329 mha of land, only 266 mha possess any potential for production. Of this, 143 mha is agricultural land nearly and 85 suffers from varying degrees of soil degradation. Of the remaining 123 mha, 40 are completely unproductive. The remaining 83 mha is classified as forest land, of which over half is denuded to various degrees. Nearly 406 million head of livestock have to be supported on 13 mha, or less than 4 per cent of the land classified as pasture land, most of which is overgrazed. Thus, our of 226 mha, about 175 mha or 66 per cent is degraded to varying degrees. Water and wind erosion causes further degradation of almost 150 mha This degradation is to be avoided.

**7. Reorientation of Institutions**

The people should be roused to orient institutions, attitudes and infrastructures, to suit conditions and needs today. The change has to be brought in keeping in view India's traditions for resources use managements and education etc. Change should be brought in education, in attitudes, in administrative procedures and in institutions. Because it affects way people view technology resources and development.

**8. Reduction of Genetic Diversity**

Proper measures to conserve genetic diversity need to be taken. At present most wild genetic stocks have been disappearing from nature. Wilding including the Asiatic Lion are facing problem of loss of genetic diversity. The protected areas network like sanctuaries, national parks,

biosphere reserves are isolating populations. So, they are decreasing changes of one group breeding with another. Remedial steps are to be taken to check decreasing genetic diversity.

**9. Evil Consequences of Urbanisation**

Nearly 27 per cent Indians live in urban areas. Urbanisation and industrialisation has given birth to a great number of environmental problem that need urgent attention. Over 30 percent of urban Indians live in slums. Out of India's 3,245 towns and cities, only 21 have partial or full sewerage and treatment facilities. Hence, coping with rapid urbanization is a major challenge.

**10. Air and water Population**

Majority of our industrial plants are using outdated and population technologies and makeshift facilities devoid of any provision of treating their wastes. A great number of cities and industrial areas that have been identified as the worst in terms of air and water pollution. Acts are enforced in the country, but their implement is not so easy. The reason is their implementation needs great resources, technical expertise, political and social will.

Again the people are to be made aware of these rules. Their support is indispensable to implement these rules.

**Ecology and ecosystems:**

Ecology is the science that deals with the relationships between living organisms with their physical environment and with each other. Ecology can be approached from the viewpoints of (1) the environment and the demands it places on the organisms in it or (2) organisms and how they adapt to their environmental conditions.

Ecology may be divided into several types such as:

**Autecology:** it is the study of individual species in relation to environment. Each stage in the life cycle of a plant or animal is greatly influenced by a number of environmental factors. There is so much synchronization of the phonological behaviour of the species and environment that what is called as **biological clocks** or **ecological clocks**. This clocks are regulated by external signals from the environment. Thus, climatic factors interact differently at various stages in the life cycle.

**Population ecology:** it is the study of individuals of the same species occupying a particular area at a specific time. Each population has certain chartacteristics such as population size and density, dispersion, age structure, natality (birth rate), mortality (death rate) and life tables. A population found in an area is also called local population. A local population genetically adapted to a particular environment is called **ecotype** and when two ecotypes meet and interbreed, it formed an **ecoline**.

**Community ecology**: in nature, different kinds of organisms grow in association with each other. A group of several species (plant or animal) living together with mutual tolerance and beneficial interaction is a community. In community organism share the same habitat. A forest, grassland, desert etc. are structures of community with certain characteristics like species diversity, growth form, dominance, succession etc.

**Lecture No. : 02**

## Natural resources and renewable resources

Our environment provides us with a variety of goods and services necessary for our day to day lives. These **natural resources** include, air, water, soil, minerals, along with the climate and solar energy, which form the non-living or **'abiotic'** part of nature. The **'biotic'** or living parts of nature consists of plants and animals, including microbes. Plants and animals can only survive as communities of different organisms, all closely linked to each in their own **habitat**, and requiring specific abiotic conditions. Thus, forests, grasslands, deserts, mountains, rivers, lakes and the marine environment all form habitats for specialised communities of plants and animals to live in. Interactions between the abiotic aspects of nature and specific living organisms together form **ecosystems** of various types. Many of these living organisms are used as our food resources. Others are linked to our food less directly, such as pollinators and dispersers of plants, soil animals like worms, which recycle nutrients for plant growth, and fungi and termites that break up dead plant material so that micro-organisms can act on the detritus to reform soil nutrients.

**Non-renewable resources**

These are minerals that have been formed in the lithosphere over millions of years and constitute a closed system. These non-renewable resources, once used, remain on earth in a different form and, unless recycled, become waste material. Non-renewable resources include fossil fuels such as oil and coal, which if extracted at the present rate, will soon be totally used up. The end products of fossil fuels are in the form of heat and mechanical energy and chemical compounds, which cannot be reconstituted as a resource.

**Renewable resources**

Though water and biological living resources are considered renewable. They are in fact renewable only within certain limits. They are linked to natural cycles such as the water cycle.

1.Fresh water (even after being used) is evaporated by the sun's energy, forms water vapour and is reformed in clouds and falls to earth as rain. However, water sources can be overused or wasted to such an extent that they locally run dry. Water sources can be so heavily polluted by sewage and toxic substances that it becomes impossible to use the water.

2.Forests, once destroyed take thousands of years to regrow into fully developed natural ecosystems with their full complement of species. Forests thus can be said to behave like non-renewable resources if overused.

3.Fish are today being over-harvested until the catch has become a fraction of the original resource and the fish are incapable of breeding successfully to replenish the population.

• The output of agricultural land if mismanaged drops drastically.

• When the population of a species of plant or animal is reduced by human activities, until it cannot reproduce fast enough to maintain a viable number, the species becomes extinct.

• Many species are probably becoming extinct without us even knowing, and other linked species are affected by their loss.

**Forest Resources**

Scientists estimate that India should ideally have 33 percent of its land under forests. Today we have only about 12 percent. Thus we need not only to protect existing forests but also to increase our forest cover. People who live in or near forests know the value of forest resources first hand because their lives and livelihoods depend directly on these resources. However, the rest of us also derive great benefits from the forests which we are rarely aware of. The water we use depends on the existence of forests on the watersheds around river valleys. Our homes, furniture and paper are made from wood from the forest. We use many medicines that are based on forest produce. And we depend on the oxygen that plants give out and the removal of carbon dioxide we breathe out from the air.

Forests once extended over large tracts of our country. People have used forests in our country for thousands of years. As agriculture spread the forests were left in patches which were controlled mostly by tribal people. They hunted animals and gathered plants and lived entirely on forest resources. Deforestation became a major concern in British times when a large amount of timber was extracted for building their ships. This led the British to develop scientific forestry in India. They however alienated local people by creating Reserved and Protected Forests which curtailed access to the resources. This led to a loss of stake in the conservation of the forests which led to a gradual degradation and fragmentation of forests across the length and breadth of the country.

Another period of overutilization and forest degradation occurred in the early period following independence as people felt that now that the British had gone they had a right to using our forests in any way we pleased. The following years saw India's residual forest wealth dwindle sharply. Timber extraction continued to remain the Forest Department's main concern up to the 1970s. The fact that forest degradation and deforestation was creating a serious loss of the important functions of the forest began to override its utilisation as a source of revenue from timber.

**Deforestation:** Where civilizations have looked after forests by using forest resources cautiously, they have prospered, where forests were destroyed, the people were gradually

impoverished. Today logging and mining are serious causes of loss of forests in our country and all over the world. Dams built for hydroelectric power or irrigation have submerged forests and have displaced tribal people whose lives are closely knit to the forest. This has become a serious cause of concern in India.

One of India's serious environmental problems is forest degradation due to timber extraction and our dependence on fuel wood. A large number of poor rural people are still highly dependent on wood to cook their meals and heat their homes. We have not been able to plant enough trees to support the need for timber and fuel wood. The National Forest Policy of 1988 now gives an added importance to JFM. Another resolution in 1990 provided a formal structure for community participation though the formation of Village Forest Committees. Based on these experiences, new JFM guidelines were issued in 2000. This stipulates that at least 25 per cent of the income from the area must go to the community. From the initiation of the program, until 2002, there were 63,618 JFM Committees managing over 140,953 sq. km of forest under JFM in 27 States in India. The States have tried a variety of approaches to JFM. The share for village forest committees ranges from 25 per cent in Kerala to 100 per cent in Andhra Pradesh, 50 per cent in Gujarat, Maharashtra, Orissa and Tripura. In many States 25 per cent of the revenue is used for village development. In many States non-timber forest products (NTFPs) are available for people free of cost. Some States have stopped grazing completely; some have rotational grazing schemes which have helped in forest regeneration.

**Timber extraction, mining and dams** are invariably parts of the needs of a developing country. If timber is overharvested the ecological functions of the forest are lost. Unfortunately forests are located in areas where there are rich mineral resources. Forests also cover the steep embankments of river valleys, which are ideally suited to develop hydel and irrigation projects. Thus there is a constant conflict of interests be- tween the conservation interests of environmental scientists and the Mining and Irrigation Departments.

What needs to be understood is that long-term ecological gains cannot be sacrificed for short-term economic gains that unfortunately lead to deforestation. These forests where development projects are planned, can displace thousands of tribal people who lose their homes when these plans are executed. This leads to high levels of suffering for which there is rarely a satisfactory answer.

**Water resources**

The water cycle, through evaporation and precipitation, maintains hydrological systems which form rivers and lakes and support in a variety of aquatic ecosystems. Wetlands are intermediate

forms between terrestrial and aquatic ecosystems and contain species of plants and animals that are highly moisture dependent. All aquatic ecosystems are used by a large number of people for their daily needs such as drinking water, washing, cooking, watering animals, and irrigating fields. The world depends on a limited quantity of fresh water. Water covers 70% of the earth's surface but only 3% of this is fresh water. Of this, 2% is in polar ice caps and only 1% is usable water in rivers, lakes and subsoil aquifers. Only a fraction of this can be actually used. At a global level 70% of water is used for agriculture about 25% for industry and only 5% for domestic use. However this varies in different countries and industrialized countries use a greater percentage for industry. India uses 90% for agriculture, 7% for industry and 3% for domestic use.

One of the greatest challenges facing the world in this century is the need to rethink the overall management of water resources. The world population has passed the 6 billion mark. Based on the proportion of young people in developing countries, this will continue to increase significantly during the next few decades. This places enormous demands on the world's limited freshwater supply. The total annual freshwater withdrawals today are estimated at 3800 cubic kilometers, twice as much as just 50 years ago (World Commission on Dams, 2000). Studies indicate that a person needs a minimum of 20 to 40 liters of water per day for drinking and sanitation. More than one billion people worldwide have no access to clean water, and to many more, supplies are unreliable.

Local conflicts are already spreading to states. Eg. Karnataka and Tamil Nadu over the waters of the Krishna. India is expected to face critical levels of water stress by 2025. At the global level 31 countries are already short of water and by 2025 there will be 48 countries facing serious water shortages. The UN has estimated that by the year 2050, 4 billion people will be seriously affected by water shortages. This will lead to multiple conflicts between countries over the sharing of water. Around 20 major cities in India face chronic or interrupted water shortages. There are 100 countries that share the waters of 13 large rivers and lakes. The upstream countries could starve the downstream nations leading to political unstable areas across the world. Examples are Ethopia, which is upstream on the Nile and Egypt, which is downstream and highly dependent on the Nile. International accords that will look at a fair distribution of water in such areas will become critical to world peace. India and Bangladesh already have a negotiated agreement on the water use of the Ganges.

**Overutilization and pollution of surface and groundwater:** With the growth of human population there is an increasing need for larger amounts of water to fulfill a variety of basic needs. Today in many areas this requirement cannot be met. Overutilization of water occurs at

various levels. Most people use more water than they really need. Most of us waste water during a bath by using a shower or during washing of clothes. Many agriculturists use more water than necessary to grow crops. There are many ways in which farmers can use less water without reducing yields such as the use of drip irrigation systems. Agriculture also pollutes surface water and underground water stores by the excessive use of chemical fertilizers and pesticides. Methods such as the use of biomass as fertilizer and non toxic pesticides such as neem products and using integrated pest management systems reduces the agricultural pollution of surface and ground water.

Industry tends to maximise short-term economic gains by not bothering about its liquid waste and releasing it into streams, rivers and the sea. In the longer term, as people become more conscious of using 'green products' made by ecosensitive industries, the polluter's products may not be used. The polluting industry that does not care for the environment and pays off bribes to get away from the cost needed to use effluent treatment plants may eventually be caught, punished and even closed down. Public awareness may increasingly put pressures on industry to produce only eco-friendly products which are already gaining in popularity. As people begin to learn about the serious health hazards caused by pesticides in their food, public awareness can begin putting pressures on farmers to reduce the use of chemicals that are injurious to health.

**Global climate change:** Changes in climate at a global level caused by increasing air pollution have now begun to affect our climate. In some regions global warming and the El Nino winds have created unprecedented storms. In other areas, they lead to long droughts. Everywhere the 'greenhouse effect' due to atmospheric pollution is leading to increasingly erratic and unpredictable climatic effects. This has seriously affected regional hydrological conditions.

**Floods:** Floods have been a serious environmental hazard for centuries. However, the havoc raised by rivers overflowing their banks has become progressively more damaging, as people have deforested catchments and intensified use of river flood plains that once acted as safety valves. Wetlands in flood plains are nature's flood control systems into which overfilled rivers could spill and act like a temporary sponge holding the water, and preventing fast flowing water from damaging surrounding land. Deforestation in the Himalayas causes floods that year after year kill people, damage crops and destroy homes in the Ganges and its tributaries and the Bramhaputra. Rivers change their course during floods and tons of valuable soil is lost to the sea. As the forests are degraded, rainwater no longer percolates slowly into the subsoil but runs off down the mountainside bearing large amounts of topsoil. This blocks rivers temporarily but gives way as the pressure mounts allowing enormous quantities of water to wash suddenly down

into the plains below. There, rivers swell, burst their banks and flood waters spread to engulf peoples' farms and homes.

**Drought:** In most arid regions of the world the rains are unpredictable. This leads to periods when there is a serious scarcity of water to drink, use in farms, or provide for urban and industrial use.

**Food resources**

Today our food comes almost entirely from agriculture, animal husbandry and fishing. Although India is self-sufficient in food production, it is only because of modern patterns of agriculture that are unsustainable and which pollute our environment with excessive use of fertilizers and pesticides. The FAO defines sustainable agriculture as that which conserves land, water and plant and animal genetic resources, does not degrade the environment and is economically viable and socially acceptable. Most of our large farms grow single crops (monoculture). If this crop is hit by a pest, the entire crop can be devastated, leaving the farmer with no income during the year.

On the other hand, if the farmer uses traditional varieties and grows several different crops, the chance of complete failure is lowered considerably. Many studies have shown that one can use alternatives to inorganic fertilizers and pesticides. This is known as **Integrated Crop Management**.

**World food problems:** In many developing countries where populations are expanding rapidly, the production of food is unable to keep pace with the growing demand. Food production in 64 of the 105 developing countries is lagging behind their population growth levels. These countries are unable to produce more food, or do not have the financial means to import it. India is one of the countries that have been able to produce enough food by cultivating a large proportion of its arable land through irrigation. The Green Revolution of the 60's reduced starvation in the country. However many of the technologies we have used to achieve this are now being questioned.

• Our fertile soils are being exploited faster than they can recuperate.

• Forests, grasslands and wetlands have been converted to agricultural use, which has led to serious ecological questions.

• Our fish resources, both marine and inland, show evidence of exhaustion.

• There are great disparities in the availability of nutritious food. Some communities such as tribal people still face serious food problems leading to malnutrition especially among women and children.

These issues bring in new questions as to how demands will be met in future even with a slowing of population growth. Today the world is seeing a changing trend in dietary habits. As living standards are improving, people are eating more non-vegetarian food. As people change from eating grain to meat, the world's demand for feed for livestock based on agriculture increases as well. This uses more land per unit of food produced and the result is that the world's poor do not get enough to eat. Women play an extremely vital role in food production as well as cooking the meal and feeding children. In most rural communities they have the least exposure to technical training and to health workers trained in teaching/learning on issues related to nutritional aspects. Women and irls frequently receive less food than the men. These disparities need to be corrected. In India there is a shortage of cultivable productive land. Thus farm sizes are too small to support a family on farm produce alone. With each generation, farms are being subdivided further. Poor environmental agricultural practices such as slash and burn, shifting cultivation, or 'rab' (woodash) cultivation degrade forests. Globally 5 to 7 million hectares of farmland is degraded each year. Loss of nutrients and overuse of agricultural chemicals are major factors in land degradation. Water scarcity is an important aspect of poor agricultural outputs.

Stalinization and water logging has affected a large amount of agricultural land worldwide. Loss of genetic diversity in crop plants is another issue that is leading to a fall in agricultural produce. Rice, wheat and corn are the staple foods of two thirds of the world's people. As wild relatives of crop plants in the world's grasslands, wetlands and other natural habitats are being lost, the ability to enhance traits that are resistant to diseases, salinity, etc. is lost. Genetic engineering is an untried and risky alternative to traditional cross breeding.

**Food Security:** It is estimated that 18 million people worldwide, most of whom are children, die each year due to starvation or malnutrition, and many others suffer a variety of dietary deficiencies. The earth can only supply a limited amount of food. If the world's carrying capacity to produce food cannot meet the needs of a growing population, anarchy and conflict will follow. Thus food security is closely linked with population control through the family welfare program. It is also linked to the availability of water for farming. Food security is only possible if food is equitably distributed to all. Many of us waste a large amount of food carelessly. This eventually places great stress on our environmental resources. A major concern is the support needed for small farmers so that they remain farmers rather than shifting to urban centers as unskilled

industrial workers. International trade policies in regard to an improved flow of food across national borders from those who have surplus to those who have a deficit in the developing world is another issue that is a concern for planners who deal with International trade concerns. 'Dumping' of underpriced foodstuffs produced in the developed world, onto markets in undeveloped countries undermines prices and forces farmers there to adopt unsustainable practices to compete.

**Fisheries:** Fish is an important protein food in many parts of the world. This includes marine and fresh water fish. While the supply of food from fisheries increased phenomenally between 1950 and 1990, in several parts of the world fish catch has since dropped due to overfishing. In 1995 FAO reported that 44% of the world's fisheries are fully or heavily exploited, 16% are already overexploited, 6% are depleted, and only 3% are gradually recovering. Canada had to virtually close down cod fishing in the 1990s due to depletion of fish reserves. Modern fishing technologies using mechanized trawlers and small meshed nets lead directly to overexploitation, which is not sustainable. It is evident that fish have to breed successfully and need to have time to grow if the yield has to be used sustainably. The worst hit are the small traditional fishermen who are no match for organized trawlers.

**Loss of Genetic diversity:** There are 50,000 known edible plants documented worldwide. Of these only 15 varieties produce 90% of the world's food. Modern agricultural practices have resulted in a serious loss of genetic variability of crops. India's distinctive traditional varieties of rice alone are said to have numbered between 30 and 50 thousand. Most of these have been lost to the farmer during the last few decades as multinational seed companies push a few commercial types.

**Alternate food sources:** Food can be innovatively produced if we break out of the current agricultural patterns. This includes working on new avenues to produce food, such as using forests for their multiple non-wood forest products, which can be used for food if harvested sustainably. This includes fruit, mushrooms, sap, gum, etc. This takes time, as people must develop a taste for these new foods.

**Energy resources**

**Energy is defined by physicists as the capacity to do work**. Energy is found on our planet in a variety of forms, some of which are immediately useful to do work, while others require a process of transformation. The sun is the primary energy source in our lives. We use it directly for its warmth and through various natural processes that provide us with food, water, fuel and shelter. The sun's rays power the growth of plants, which form our food material, give off oxygen which we breathe in and take up carbon dioxide that we breathe out. Energy from the sun

evaporates water from oceans, rivers and lakes, to form clouds that turn into rain. Today's fossil fuels were once the forests that grew in prehistoric times due to the energy of the sun.

Chemical energy, contained in chemical compounds is released when they are broken down by animals in the presence of oxygen. In India, manual labour is still extensively used to get work done in agricultural systems, and domestic animals used to pull carts and ploughs. Electrical energy produced in several ways, powers transport, artificial lighting, agriculture and industry.

This comes from hydel power based on the water cycle that is powered by the sun's energy that supports evaporation, or from thermal power stations powered by fossil fuels. Nuclear energy is held in the nucleus of an atom and is now harnessed to develop electrical energy. We use energy for household use, agriculture, production of industrial goods and for running transport. Modern agriculture uses chemical fertilizers, which require large amounts of energy during their manufacture.

Industry uses energy to power manufacturing units and the urban complexes that support it. Energy-demanding roads and railway lines are built to transport products from place to place and to reach raw materials in mines and forests No energy related technology is completely 'risk free' and unlimited demands on energy increase this risk factor many fold. All energy use creates heat and contributes to atmospheric temperature. Many forms of energy release carbon dioxide and lead to global warming. Nuclear energy plants have caused enormous losses to the environment due to the leakage of nuclear material. The inability to effectively manage and safely dispose of nuclear waste is a serious global concern. At present almost 2 billion people worldwide have no access to electricity at all. While more people will require electrical energy, those who do have access to it continue to increase their individual requirements. In addition, a large proportion of energy from electricity is wasted during transmission as well as at the user level. It is broadly accepted that long-term trends in energy use should be towards a cleaner global energy system that is less carbon intensive and less reliant on finite non-renewable energy sources. It is estimated that the currently used methods of using renewable energy and non renewable fossil fuel sources together will be insufficient to meet foreseeable global demands for power generation beyond the next 50 to 100 years. Thus when we use energy wastefully, we are contributing to a major environmental disaster for our earth. We all need to become responsible energy users. An electrical light that is burning unnecessarily is a contributor to environmental degradation.

**Growing energy needs**: Energy has always been closely linked to man's economic growth and development. Present strategies for development that have focused on rapid economic growth have used energy utilization as an index of economic development. This index however, does not

take into account the long-term ill effects on society of excessive energy utilisation. In 1998, the World Resources Institute found that the average American uses 24 times the energy used by an Indian.

Between 1950 and 1990, the world's energy needs increased four folds. The world's demand for electricity has doubled over the last 22 years! The world's total primary energy consumption in 2000 was 9096 million tons of oil. A global average per capita that works out to be 1.5 tons of oil. Electricity is at present the fastest growing form of end-use energy worldwide. By 2005 the Asia-Pacific region is expected to surpass North America in energy consumption and by 2020 is expected to consume some 40% more energy than North America. For almost 200 years, coal was the primary energy source fuelling the industrial revolution in the 19th century. At the close of the 20th century, oil accounted for 39% of the world's commercial energy consumption, followed by coal (24%) and natural gas (24%), while nuclear (7%) and hydro/renewables (6%) accounted for the rest.

Among the commercial energy sources used in India, coal is a predominant source accounting for 55% of energy consumption estimated in 2001, followed by oil (31%), natural gas (8%), hydro (5%) and nuclear (1%). In India, biomass (mainly wood and dung) accounts for almost 40% of primary energy supply. While coal continues to remain the dominant fuel for electricity generation, nuclear power has been increasingly used since the 1970s and 1980s and the use of natural gas has increased rapidly in the 80s and 90s.

**Land resources:**

**Land as a resource**: Landforms such as hills, valleys, plains, river basins and wetlands include different resource generating areas that the people living in them depend on. Many traditional farming societies had ways of preserving areas from which they used resources. Eg. In the 'sacred groves' of the Western Ghats, requests to the spirit of the Grove for permission to cut a tree, or extract a resource, were accompanied by simple rituals. The outcome of a chance fall on one side or the other of a stone balanced on a rock gave or withheld permission. The request could not be repeated for a specified period. If land is utilized carefully it can be considered a renewable resource.

The roots of trees and grasses bind the soil. If forests are depleted, or grasslands overgrazed, the land becomes unproductive and wasteland is formed. Intensive irrigation leads to water logging and salination, on which crops cannot grow. Land is also converted into a non-renewable resource when highly toxic industrial and nuclear wastes are dumped on it.

Land on earth is as finite as any of our other natural resources. While mankind has learnt to adapt his lifestyle to various ecosystems world over, he cannot live comfortably for instance on polar

ice caps, on under the sea, or in space in the foreseeable future. Man needs land for building homes, cultivating food, maintaining pastures for domestic animals, developing industries to provide goods, and supporting the industry by creating towns and cities. Equally importantly, man needs to protect wilderness area in forests, grasslands, wetlands, mountains, coasts, etc. to protect our vitally valuable biodiversity. Thus a rational use of land needs careful planning. One can develop most of these different types of land uses almost anywhere, but Protected Areas (National Park's and Wildlife Sanctuaries) can only be situated where some of the natural ecosystems are still undisturbed. These Protected Areas are important aspects of good land use planning.

**Land Degradation:** Farmland is under threat due to more and more intense utilisation. Every year, between 5 to 7 million hectares of land worldwide is added to the existing degraded farmland. When soil is used more intensively by farming, it is eroded more rapidly by wind and rain. Over irrigating farmland leads to salinisation, as evaporation of water brings the salts to the surface of the soil on which crops cannot grow. Over irrigation also creates water logging of the topsoil so that crop roots are affected and the crop deteriorates. The use of more and more chemical fertilizers poisons the soil so that eventually the land becomes unproductive. As urban centers grow and industrial expansion occurs, the agricultural land and forests shrink. This is a serious loss and has long term ill effects on human civilisation.

**Soil erosion:** The characteristics of natural ecosystems such as forests and grasslands depend on the type of soil. Soils of various types support a wide variety of crops. The misuse of an ecosystem leads to loss of valuable soil through erosion by the monsoon rains and, to a smaller extent, by wind. The roots of the trees in the forest hold the soil. Deforestation thus leads to rapid soil erosion. Soil is washed into streams and is transported into rivers and finally lost to the sea. The process is more evident in areas where deforestation has led to erosion on steep hill slopes as in the Himalayas and in the Western Ghats. These areas are called 'ecologically sensitive areas' or ESAs. To prevent the loss of millions of tons of valuable soil every year, it is essential to preserve what remains of our natural forest cover. It is equally important to reforest denuded areas. The linkage between the existence of forests and the presence of soil is greater than the forest's physical soil binding function alone. The soil is enriched by the leaflitter of the forest. This detritus is broken down by soil micro-organisms, fungi, worms and insects, which help to recycle nutrients in the system. Further losses of our soil wealth will impoverish our country and reduce its capacity to grow enough food in future.

## Lecture 03

# Ecosystems: Concept, Structure and Functions

**Concept of an Ecosystem:**

Living organisms cannot live isolated from their non-living environment because the latter provides materials and energy for the survival of the former i.e. there is interaction between a biotic community and its environment to produce a stable system; a natural self-sufficient unit which is known as an ecosystem.

An ecosystem is, therefore, defined as a natural functional ecological unit comprising of living organisms (biotic community) and their non-living (abiotic or physio chemical) environment that interact to form a stable self-supporting system. A pond, lake, desert, grassland, meadow, forest etc. are common examples of ecosystems.

**Structure and Function of an Ecosystem:**

**Each ecosystem has two main components:**

(1) Abiotic

(2) Biotic

**(1) Abiotic Components:**

The non living factors or the physical environment prevailing in an ecosystem form the abiotic components. They have a strong influence on the structure, distribution, behaviour and inter-relationship of organisms.

**Abiotic components are mainly of two types:**

**(a) Climatic Factors:**

Which include rain, temperature, light, wind, humidity etc.

**(b) Edaphic Factors:**

Which include soil, pH, topography minerals etc.?

**The functions of important factors in abiotic components are given below:**

Soils are much more complex than simple sediments. They contain a mixture of weathered rock fragments, highly altered soil mineral particles, organic matter, and living organisms. Soils provide nutrients, water, a home, and a structural growing medium for organisms. The vegetation found growing on top of a soil is closely linked to this component of an ecosystem through nutrient cycling.

The atmosphere provides organisms found within ecosystems with carbon dioxide for photosynthesis and oxygen for respiration. The processes of evaporation, transpiration and precipitation cycle water between the atmosphere and the Earth's surface.

Solar radiation is used in ecosystems to heat the atmosphere and to evaporate and transpire water into the atmosphere. Sunlight is also necessary for photosynthesis.

Photosynthesis provides the energy for plant growth and metabolism, and the organic food for other forms of life.

Most living tissue is composed of a very high percentage of water, up to and even exceeding 90%. The protoplasm of a very few cells can survive if their water content drops below 10%, and most are killed if it is less than 30-50%. Water is the medium by which mineral nutrients enter and are trans-located in plants. It is also necessary for the maintenance of leaf turgidity and is required for photosynthetic chemical reactions. Plants and animals receive their water from the Earth's surface and soil. The original source of this water is precipitation from the atmosphere.

**(2) Biotic Components:**

The living organisms including plants, animals and micro-organisms (Bacteria and Fungi) that are present in an ecosystem form the biotic components.

**On the basis of their role in the ecosystem the biotic components can be classified into three main groups:**

(A) Producers

(B) Consumers

(C) Decomposers or Reducers.

**(A) Producers:**

The green plants have chlorophyll with the help of which they trap solar energy and change it into chemical energy of carbohydrates using simple inorganic compounds namely water and carbon dioxide. This process is known as photosynthesis. As the green plants manufacture their own food they are known as Autotrophs (i.e. auto = self, trophos = feeder)

The chemical energy stored by the producers is utilised partly by the producers for their own growth and survival and the remaining is stored in the plant parts for their future use.

**(B) Consumers:**

The animals lack chlorophyll and are unable to synthesise their own food. Therefore, they depend on the producers for their food. They are known as heterotrophs (i.e. heteros = other, trophos = feeder)

**The consumers are of four types, namely:**

**(a) Primary Consumers or First Order Consumers or Herbivores:**

These are the animals which feed on plants or the producers. They are called herbivores. Examples are rabbit, deer, goat, cattle etc.

**(b) Secondary Consumers or Second Order Consumers or Primary Carnivores:**

The animals which feed on the herbivores are called the primary carnivores. Examples are cats, foxes, snakes etc.

**(c) Tertiary Consumers or Third Order Consumers:**

These are the large carnivores which feed on the secondary consumers. Examples are Wolves.

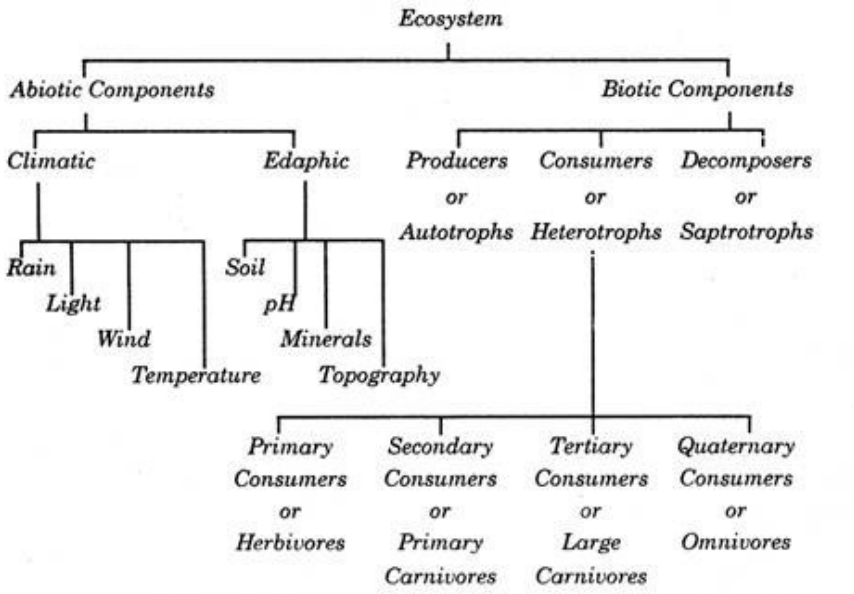
**(d) Quaternary Consumers or Fourth Order Consumers or Omnivores:**

These are the largest carnivores which feed on the tertiary consumers and are not eaten up by any other animal. Examples are lions and tigers.

**(C) Decomposers or Reducers:**

Bacteria and fungi belong to this category. They breakdown the dead organic materials of producers (plants) and consumers (animals) for their food and release to the environment the simple inorganic and organic substances produced as by-products of their metabolisms.

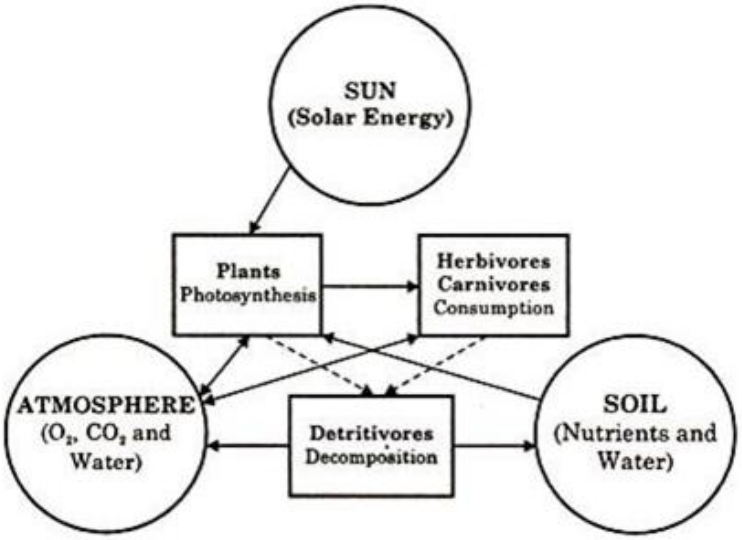
These simple substances are reused by the producers resulting in a cyclic exchange of materials between the biotic community and the abiotic environment of the ecosystem. The decomposers are known as Saprotrophs (i.e., sapros = rotten, trophos = feeder)




**Schematic Representation of the Structure of an Ecosystem.**

**Lecture No. : 04**

# Energy Flow in ecosystem




**Relationship within an Ecosystem.**

**Energy Flow in ecosystem:**

The main concepts we are trying to get across in this section concern how energy moves through an ecosystem. If you can understand this, you are in good shape, because then you have an idea of how ecosystems are balanced, how they may be affected by human activities, and how pollutants will move through an ecosystem. If you had Biology 101, this should be review; if you had Geology 101, this is new stuff. Either way, it is pretty basic and you shouldn't have much trouble reading this material or the associated material in the text.

**Roles of Organisms**

Organisms can be either *producers* or *consumers* in terms of energy flow through an ecosystem. Producers convert energy from the environment into carbon bonds, such as those found in the sugar glucose. *Plants* are the most obvious examples of producers; plants take energy from sunlight and use it to convert carbon dioxide into glucose (or other sugars). Algae and cyanobacteria are also *photosynthetic* producers, like plants. Other producers include bacteria living around deep-sea vents. These bacteria take energy from chemicals coming from the Earth's interior and use it to make sugars. Other bacteria living deep underground can also produce sugars from such inorganic sources. Another word for producers is *autotrophs*.

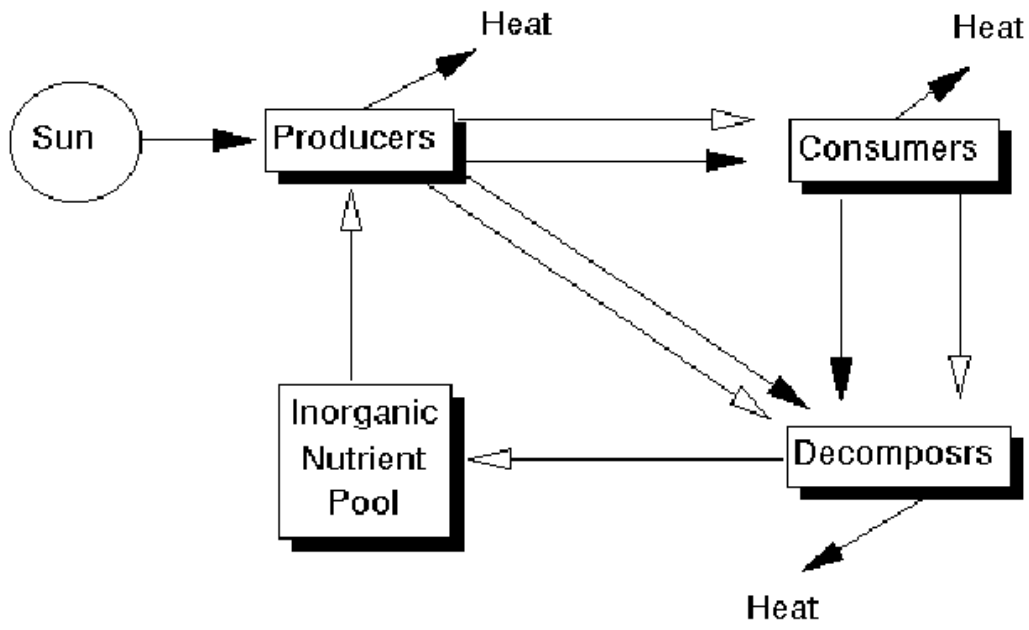
Consumers get their energy from the carbon bonds made by the producers. Another word for a consumer is a *heterotroph*. Based on what they eat, we can distinguish between 4 types of heterotrophs:

| consumer | trophic level | food source |
|---|---|---|
| Herbivores | primary | plants |
| Carnivores | secondary or higher | animals |

Omnivores all levels plants & animals

Detritivores ---------- detritus

A *trophic level* refers to the organisms position in the food chain. Autotrophs are at the base. Organisms that eat autotrophs are called *herbivores* or *primary consumers*. An organism that eats herbivores is a *carnivore* and a *secondary consumer*. A carnivore which eats a carnivore which eats a herbivore is a *tertiary consumer*, and so on. It is important to note that many animals do not specialize in their diets. *Omnivores* (such as humans) eat both animals and plants. Further, except for some specialists, most carnivores don't limit their diet to organisms of only one trophic level. Frogs, for instance, don't discriminate between herbivorous and carnivorous bugs in their diet. If it's the right size, and moving at the right distance, chances are the frog will eat it. It's not as if the frog has brain cells to waste wondering if it's going to mess up the food chain by being a secondary consumer one minute and a quaternary consumer the next.




The diagram above shows how both energy and inorganic nutrients flow through the ecosystem. We need to define some terminology first. Energy "flows" through the ecosystem in the form of carbon-carbon bonds. When respiration occurs, the carbon-carbon bonds are broken and the carbon is combined with oxygen to form carbon dioxide. This process releases the energy, which is either used by the organism (to move its muscles, digest food, excrete wastes, think, etc.) or the energy may be lost as heat. The dark arrows represent the movement of this energy. Note that all energy comes from the sun, and that the ultimate fate of all energy in ecosystems is to be lost as heat. Energy does not recycle!!

The other component shown in the diagram are the inorganic nutrients. They are inorganic because they do not contain carbon-carbon bonds. These inorganic nutrients include the

phosphorous in your teeth, bones, and cellular membranes; the nitrogen in your amino acids (the building blocks of protein); and the iron in your blood (to name just a few of the inorganic nutrients). The movement of the inorganic nutrients is represented by the open arrows. Note that the autotrophs obtain these inorganic nutrients from the inorganic nutrient pool, which is usually the soil or water surrounding the plants or algae. These inorganic nutrients are passed from organism to organism as one organism is consumed by another. Ultimately, all organisms die and become detritus, food for the decomposers. At this stage, the last of the energy is extracted (and lost as heat) and the inorganic nutrients are returned to the soil or water to be taken up again. The inorganic nutrients are recycled, the energy is not.

Many of us, when we hear the word "nutrient" immediately think of calories and the carbon-carbon bonds that hold the caloric energy. IT IS VERY IMPORTANT that you be careful in your use of the word nutrient in this sense. When writing about energy flow and inorganic nutrient flow in an ecosystem, you must be clear as to what you are referring. Unmodified by "inorganic" or "organic", the word "nutrient" can leave your reader unsure of what you mean. This is one case in which the scientific meaning of a word is very dependent on its context. Another example would be the word "respiration", which to the layperson usually refers to "breathing", but which means "the extraction of energy from carbon-carbon bonds at the cellular level" to most scientists (except those scientists studying breathing, who use respiration in the lay sense).

To summarize: In the flow of energy and inorganic nutrients through the ecosystem, a few generalizations can be made:

1. The ultimate source of energy (for most ecosystems) is the sun
2. The ultimate fate of energy in ecosystems is for it to be lost as heat.
3. Energy and nutrients are passed from organism to organism through the food chain as one organism eats another.
4. Decomposers remove the last energy from the remains of organisms.
5. Inorganic nutrients are cycled, energy is not.

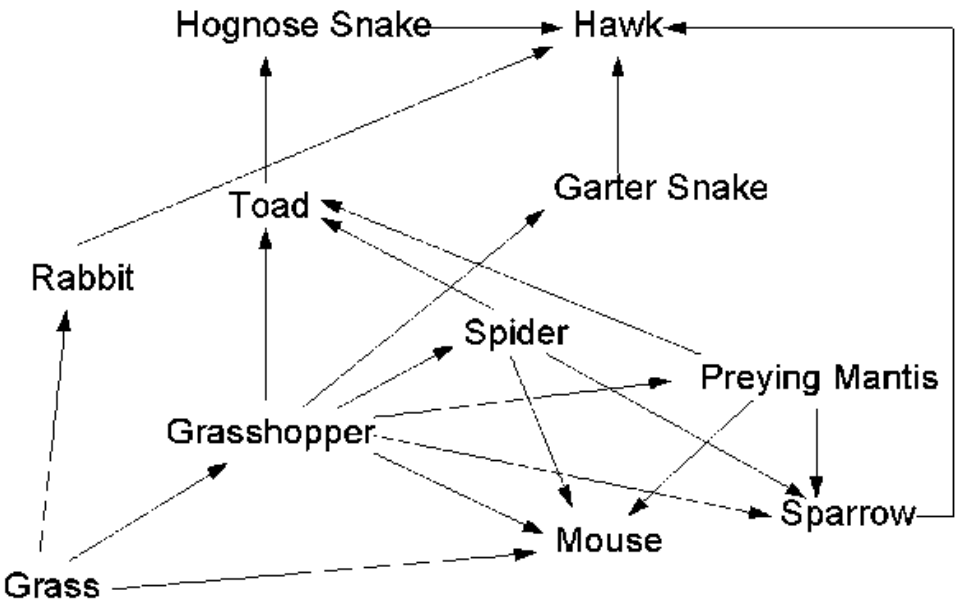
**Food Chains and Webs:**

A food chain is the path of food from a given final consumer back to a producer. For instance, a typical food chain in a field ecosystem might be:

grass ---> grasshopper --> mouse ---> snake ---> hawk

Note that even though I said the food chain is the path of food from a given final consumer back to a producer we typically list a food chain from producer on the left (or at the bottom) to final consumer on the right (or at the top). Note to international readers: In Hebrew or Aramaic, or other languages which are read right-to-left, is it customary to list the food chains in the reverse order? By the way, you should be able to look at the food chain above and identify the autotrophs and heterotrophs, and classify each as a herbivore, carnivore, etc. You should also be able to determine that the hawk is a quaternary consumer.

The real world, of course, is more complicated than a simple food chain. While many organisms do specialize in their diets (anteaters come to mind as a specialist), other organisms do not. Hawks don't limit their diets to snakes, snakes eat things other than mice, mice eat grass as well as grasshoppers, and so on. A more realistic depiction of who eats whom is called a food web; an example is shown below:




It is when we have a picture of a food web in front of us that the definition of food chain makes more sense. We can now see that a food web consists of interlocking food chains, and that the only way to untangle the chains is to trace *back* along a given food chain to its source.

The food webs you see here are *grazing food chains* since at their base are producers which the herbivores then graze on. While grazing food chains are important, in nature they are outnumbered by *detritus-based food chains*. In detritus-based food chains, decomposers are at the base of the food chain, and sustain the carnivores which feed on them. In terms of the weight (or biomass) of animals in many ecosystems, more of their body mass can be traced back to detritus than to living producers.

**Pyramids**

The concept of biomass is important. It is a general principle that the further removed a trophic level is from its source (detritus or producer), the less biomass it will contain (biomass here would refer to the combined weight of all the organisms in the trophic level). This reduction in biomass occurs for several reasons:

1. not everything in the lower levels gets eaten
2. not everything that is eaten is digested
3. energy is always being lost as heat

It is important to remember that the decrease in number is best detected in terms or biomass. Numbers of organisms are unreliable in this case because of the great variation in the biomass of *individual* organisms. For instance, squirrels feed on acorns. The oak trees in a forest will always outnumber the squirrels in terms of combined weight, but there may actually be more squirrels than oak trees. Remember that an individual oak tree is huge, weighing thousands of kilograms, while an individual squirrel weighs perhaps 1 kilogram at best. There are few exceptions to the pyramid of biomass scheme. One occurs in aquatic systems where the algae may be both outnumbered and outweighed by the organisms that feed on the algae. The algae can support the greater biomass of the next trophic level only because they can reproduce as fast as they are eaten. In this way, they are never completely consumed. It is interesting to note that this exception to the rule of the pyramid of biomass also is a partial exception to at least 2 of the

3 reasons for the pyramid of biomass given above. While not all the algae are consumed, a greater proportion of them are, and while not completely digestible, algae are far more nutritious overall than the average woody plant is (most organisms cannot digest wood and extract energy from it).

A generalization exists among ecologists that on average, about 10% of the energy available in one trophic level will be passed on to the next; this is primarily due to the 3 reasons given above. Therefore, it is also reasonable to assume that in terms of biomass, each trophic level will weigh only about 10% of the level below it, and 10x as much as the level above it. It also seems, however, that every time I go to measure, test, or model this assumption I run into an inconsistency, so take this generalization with a big grain of salt. Still, it comes in useful In terms of human diet and feeding the world's population, consider this. If we all ate corn, there would be enough food for 10x as many of us as compared to a world where we all eat beef (or chicken, fish, pork, etc.). Another way of looking at it is this. Every time you eat meat, you are taking food out of the mouths of 9 other people, who could be fed with the plant material that was fed to the animal you are eating. Of course, it's not quite that simple, but you get the general idea.

**Biological Magnification**

*Biological magnification* is the tendency of pollutants to become concentrated in successive trophic levels. Often, this is to the detriment of the organisms in which these materials concentrate, since the pollutants are often toxic.

Biomagnification occurs when organisms at the bottom of the food chain concentrate the material above its concentration in the surrounding soil or water. Producers, as we saw earlier, take in inorganic nutrients from their surroundings. Since a lack of these nutrients can limit the growth of the producer, producers will go to great lengths to obtain the nutrients. They will spend considerable energy to pump them into their bodies. They will even take up more than they need immediately and store it, since they can't be "sure" of when the nutrient will be available again (of course, plants don't think about such things, but, as it turns out, those plants, which, for whatever reason, tended to concentrate inorganic nutrients have done better over the years). The problem comes up when a pollutant, such as DDT or mercury, is present in the environment. Chemically, these pollutants resemble essential inorganic nutrients and are brought into the producer's body and stored "by mistake". This is the first step in biomagnification; the pollutant is at a higher concentration inside the producer than it is in the environment.

The second stage of biomagnification occurs when the producer is eaten. Remember from our discussion of a pyramid of biomass that relatively little energy is available from one trophic level to the next. This means that a consumer (of any level) has to consume a lot of biomass from the lower trophic level. If that biomass contains the pollutant, the pollutant will be taken up in large quantities by the consumer. Pollutants that biomagnify have another characteristic. Not only are they taken up by the producers, but they are absorbed and stored in the bodies of the consumers. This often occurs with pollutants soluble in fat such as DDT or PCB's. These materials are digested from the producer and move into the fat of the consumer. If the consumer is caught and eaten, its fat is digested and the pollutant moves to the fat of the new consumer. In this way, the pollutant builds up in the fatty tissues of the consumers. Water-soluble pollutants usually cannot biomagnify in this way because they would dissolve in the bodily fluids of the

consumer. Since every organism loses water to the environment, as the water is lost the pollutant would leave as well. Alas, fat simply does not leave the body.

The "best" example of biomagnification comes from DDT. This long-lived pesticide (insecticide) has improved human health in many countries by killing insects such as mosquitoes that spread disease. On the other hand, DDT is effective in part because it does not break down in the environment. It is picked up by organisms in the environment and incorporated into fat. Even here, it does no real damage in many organisms (including humans). In others, however, DDT is deadly or may have more insidious, long-term effects. In birds, for instance, DDT interferes with the deposition of calcium in the shells of the bird's eggs. The eggs laid are very soft and easily broken; birds so afflicted are rarely able to raise young and this causes a decline in their numbers. This was so apparent in the early 1960's that it led the scientist Rachel Carson to postulate a "silent spring" without the sound of bird calls. Her book "*Silent Spring*" led to the banning of DDT, the search for pesticides that would not biomagnify, and the birth of the "modern" environmental movement in the 1960's. Birds such as the bald eagle have made comebacks in response to the banning of DDT in the US. Ironically, many of the pesticides which replaced DDT are more dangerous to humans, and, without DDT, disease (primarily in the tropics) claims more human lives.

**Human vs. Natural Food Chains**

Human civilization is dependent on agriculture. Only with agriculture can a few people feed the rest of the population; the part of the population freed from raising food can then go on to do all the things we associate with civilization. Agriculture means manipulating the environment to favor plant species that we can eat. In essence, humans manipulate competition, allowing favored species (crops) to thrive and thwarting species which might otherwise crowd them out (weeds). In essence, with agriculture we are creating a very simple ecosystem. At most, it has only three levels - producers (crops), primary consumers (livestock, humans) and secondary consumers (humans). This means that little energy is lost between tropic levels, since there are fewer trophic levels present.

This is good for humans, but what type of "ecosystem" have we created? Agricultural ecosystems have several problems. First, we create *monocultures*, or fields with only one crop. This is simplest for planting, weeding, and harvesting, but it also packs many similar plants into a small area, creating a situation ideal for disease and insect pests. In natural ecosystems, plants of one species are often scattered. Insects, which often specialize on feeding on a particular plant species, have a hard time finding the scattered plants. Without food, the insect populations are kept in check. In a field of corn however, even the most inept insect can find a new host plant with a jump in any direction. Likewise, disease is more easily spread if the plants are in close proximity. It takes lots of chemicals (pesticides) to keep a monoculture going.

Another problem with human agriculture is that we rely on relatively few plants for food. If the corn and rice crops failed worldwide in the same year, we would be hard-pressed to feed everyone (not that we're doing a great job of it now). Natural ecosystems usually have alternate sources of food available if one fails.

A final problem associated with agro ecosystems is the problem of inorganic nutrient recycling. In a natural ecosystem, when a plant dies it fall to the ground and rots, and its inorganic nutrients are returned to the soil from which they were taken. In human agriculture,

however, we harvest the crop, truck it away, and flush it down the toilet to be run off in the rivers to the ocean. Aside from the water pollution problems this causes, it should be obvious to you that the nutrients are not returned to the fields. They have to be replaced with chemical fertilizers, and that means mining, transportation, electricity, etc. Also, the chemical fertilizers tend to run off the fields (along with soil disrupted by cultivation) and further pollute the water.
Some solutions are at hand, but they bring on new problems, too. No-till farming uses herbicides to kill plants in a field; the crop is then planted through the dead plants without ploughing up the soil. This reduced soil and fertilizer erosion, but the herbicides themselves may damage ecosystems. In many areas, sewage sludge is returned to fields to act as a fertilizer. This reduces the need for chemical fertilizers, but still requires a lot of energy to haul the sludge around. Further, if one is not careful, things such as household chemicals and heavy metals may contaminate the sewage sludge and biomagnify in the crops which we would then eat.

**Lecture No: 05**

# BioGeoChemical Cycles

We have already seen that while energy does not cycle through an ecosystem, chemicals do. The inorganic nutrients cycle through more than the organisms, however, they also enter into the atmosphere, the oceans, and even rocks. Since these *chem*icals cycle through both the *bio*logical and the *geo*logical world, we call the overall cycles biogeochemical cycles. Each chemical has its own unique cycle, but all of the cycles do have some things in common. *Reservoirs* are those parts of the cycle where the chemical is held in large quantities for long periods of time. In *exchange pools*, on the other hand, the chemical is held for only a short time. The length of time a chemical is held in an exchange pool or a reservoir is termed its *residence* time. The oceans are a reservoir for water, while a cloud is an exchange pool. Water may reside in an ocean for thousands of years, but in a cloud for a few days at best. The biotic community includes all living organisms. This community may serve as an exchange pool (although for some chemicals like carbon, bound in a sequoia for a thousand years, it may seem more like a reservoir), and also serve to move chemicals from one stage of the cycle to another. For instance, the trees of the tropical rain forest bring water up from the forest floor to be evaporated into the atmosphere. Likewise, coral endosymbionts take carbon from the water and turn it into limestone rock. The energy for most of the transportation of chemicals from one place to another is provided either by the sun or by the heat released from the mantle and core of the Earth.

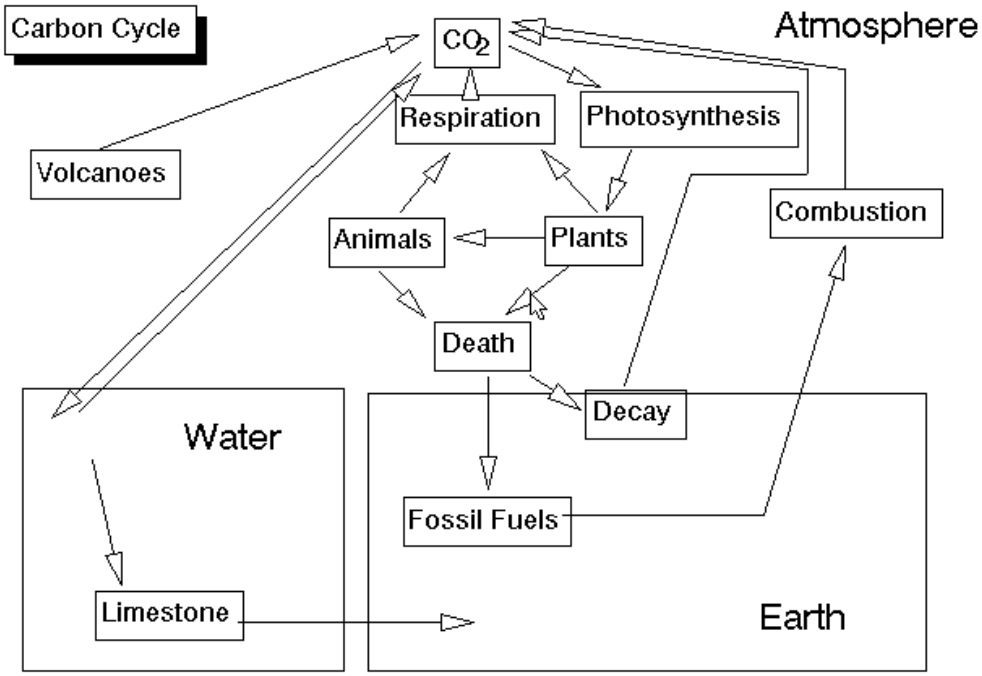
While all inorganic nutrients cycle, we will focus on only 4 of the most important cycles - water, carbon (and oxygen), nitrogen, and phosphorous.

**The Water Cycle:**

Key Features: In the water cycle, energy is supplied by the sun, which drives evaporation whether it be from ocean surfaces or from treetops. The sun also provides the energy which drives the weather systems which move the water vapor (clouds) from one place to another (otherwise, it would only rain over the oceans). Precipitation occurs when water condenses from a gaseous state in the atmosphere and falls to earth. Evaporation is the reverse process in which liquid water becomes gaseous. Once water condenses, gravity takes over and the water is pulled to the ground. Gravity continues to operate, either pulling the water underground (groundwater) or across the surface (runoff). In either event, gravity continues to pull water lower and lower until it reaches the oceans (in most cases; the Great Salt Lake, Dead Sea, Caspian Sea, and other such depressions may also serve as the lowest basin into which water can be drawn). Frozen water may be trapped in cooler regions of the Earth (the poles, glaciers on mountaintops, etc.) as snow or ice, and may remain as such for very long periods of time. Lakes, ponds, and wetlands form where water is temporarily trapped. The oceans are salty because any weathering of minerals that occurs as the water runs to the ocean will add to the mineral content

of the water, but water cannot leave the oceans except by evaporation, and evaporation leaves the minerals behind. Thus, rainfall and snowfall are comprised of relatively clean water, with the exception of pollutants (such as acids) picked up as the waster falls through the atmosphere. Organisms play an important role in the water cycle. As you know, most organisms contain a significant amount of water (up to 90% of their body weight). This water is not held for any length of time and moves out of the organism rather quickly in most cases. Animals and plants lose water through evaporation from the body surfaces, and through evaporation from the gas exchange structures (such as lungs). In plants, water is drawn in at the roots and moves to the gas exchange organs, the leaves, where it evaporates quickly. This special case is called transpiration because it is responsible for so much of the water that enters the atmosphere. In both plants and animals, the breakdown of carbohydrates (sugars) to produce energy (respiration) produces both carbon dioxide and water as waste products. Photosynthesis reverses this reaction, and water and carbon dioxide are combined to form carbohydrates. Now you understand the relevance of the term carbohydrate; it refers to the combination of carbon and water in the sugars we call carbohydrates.

**Carbon Cycle**



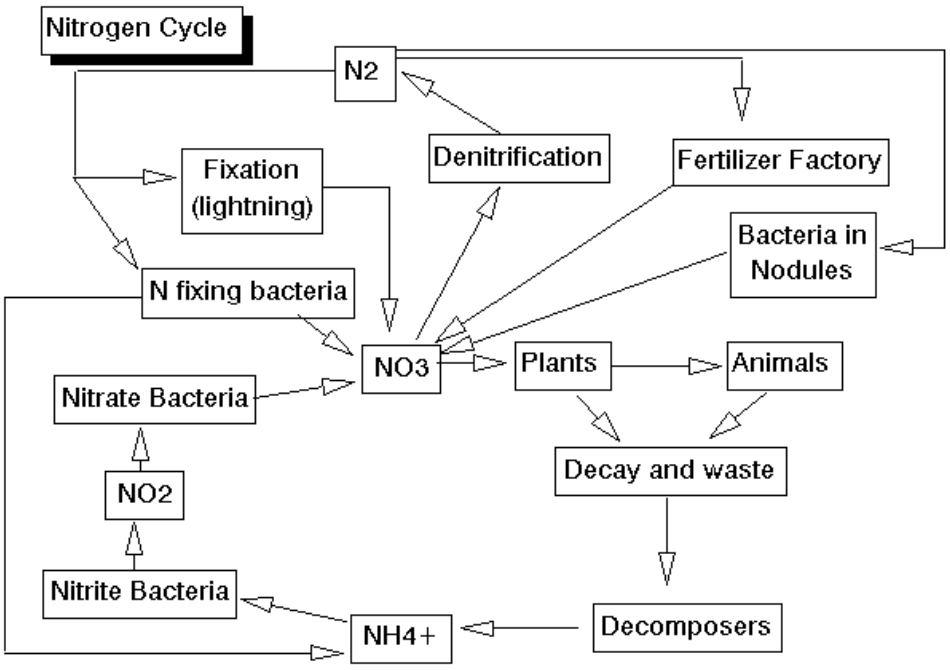

Once you understand the water cycle, the carbon cycle is relatively simple. From a biological perspective, the key events here are the complementary reactions of respiration and photosynthesis. Respiration takes carbohydrates and oxygen and combines them to produce carbon dioxide, water, and energy. Photosynthesis takes carbon dioxide and water and produces carbohydrates and oxygen. The outputs of respiration are the inputs of photosynthesis, and the outputs of photosynthesis are the inputs of respiration. The reactions are also complementary in the way they deal with energy. Photosynthesis takes energy from the sun and stores it in the carbon-carbon bonds of carbohydrates; respiration releases that energy. Both plants and animals carry on respiration, but only plants (and other producers) can carry on photosynthesis. The chief reservoirs for carbon dioxide are in the oceans and in rock. Carbon dioxide dissolves readily in

water. Once there, it may precipitate (fall out of solution) as a solid rock known as calcium carbonate (limestone). Corals and algae encourage this reaction and build up limestone reefs in the process. On land and in the water, plants take up carbon dioxide and convert it into carbohydrates through photosynthesis. This carbon in the plants now has 3 possible fates. It can be liberated to the atmosphere by the plant through respiration; it can be eaten by an animal, or it can be present in the plant when the plant dies. Animals obtain all their carbon in their food, and, thus, all carbon in biological systems ultimately comes from plants (autotrophs). In the animal, the carbon also has the same 3 possible fates. Carbon from plants or animals that is released to the atmosphere through respiration will either be taken up by a plant in photosynthesis or dissolved in the oceans. When an animal or a plant dies, 2 things can happen to the carbon in it. It can either be respired by decomposers (and released to the atmosphere), or it can be buried intact and ultimately form coal, oil, or natural gas (fossil fuels). The fossil fuels can be mined and burned in the future; releasing carbon dioxide to the atmosphere. Otherwise, the carbon in limestone or other sediments can only be released to the atmosphere when they are subducted and brought to volcanoes, or when they are pushed to the surface and slowly weathered away. Humans have a great impact on the carbon cycle because when we burn fossil fuels we release excess carbon dioxide into the atmosphere. This means that more carbon dioxide goes into the oceans, and more is present in the atmosphere. The latter condition causes global warming, because the carbon dioxide in the atmosphere allows more energy to reach the Earth from the sun than it allows to escape from the Earth into space.

**The Oxygen Cycle:**

If you look back at the carbon cycle, you will see that we have also described the oxygen cycle, since these atoms often are combined. Oxygen is present in the carbon dioxide, in the carbohydrates, in water, and as a molecule of two oxygen atoms. Oxygen is released to the atmosphere by autotrophs during photosynthesis and taken up by both autotrophs and heterotrophs during respiration. In fact, all of the oxygen in the atmosphere is *biogenic*; that is, it was released from water through photosynthesis by autotrophs. It took about 2 billion years for autotrophs (mostly cyanobacteria) to raise the oxygen content of the atmosphere to the 21% that it is today; this opened the door for complex organisms such as multicellular animals, which need a lot of oxygen.

**The Nitrogen Cycle:**




The nitrogen cycle is one of the most difficult of the cycles to learn, simply because there are so many important forms of nitrogen, and because organisms are responsible for each of the interconversions. Remember that nitrogen is critically important in forming the amino portions of the amino acids which in turn form the proteins of your body. Proteins make up skin and muscle, among other important structural portions of your body, and all enzymes are proteins. Since enzymes carry out almost all of the chemical reactions in your body, it's easy to see how important nitrogen is. The chief reservoir of nitrogen is the atmosphere, which is about 78% nitrogen. It is here we reach one of the limits of the hypertext language currently (1995-1996) most in vogue on the WWW. This version does not allow for superscripts or subscripts, so I will have to stick to the longer chemical names. Nitrogen gas in the atmosphere is composed of two nitrogen atoms bound to each other. It is a pretty non-reactive gas; it takes a lot of energy to get nitrogen gas to break up and combine with other things, such as carbon or oxygen. Nitrogen gas can be taken from the atmosphere (fixed) in two basic ways. First, lightning provides enough energy to "burn" the nitrogen and fix it in the form of nitrate, which is a nitrogen with three oxygens attached. This process is duplicated in fertilizer factories to produce nitrogen fertilizers. Biology 101 students will also recall the experiments of Stanley Miller, who used electrical discharges to show how nitrogen in the Earth's early atmosphere might have combined to form amino acids. The other form of nitrogen fixation is by nitrogen fixing bacteria, who use special enzymes instead of the extreme amount of energy found in lightning to fix nitrogen. These nitrogen-fixing bacteria come in three forms: some are free-living in the soil; some form

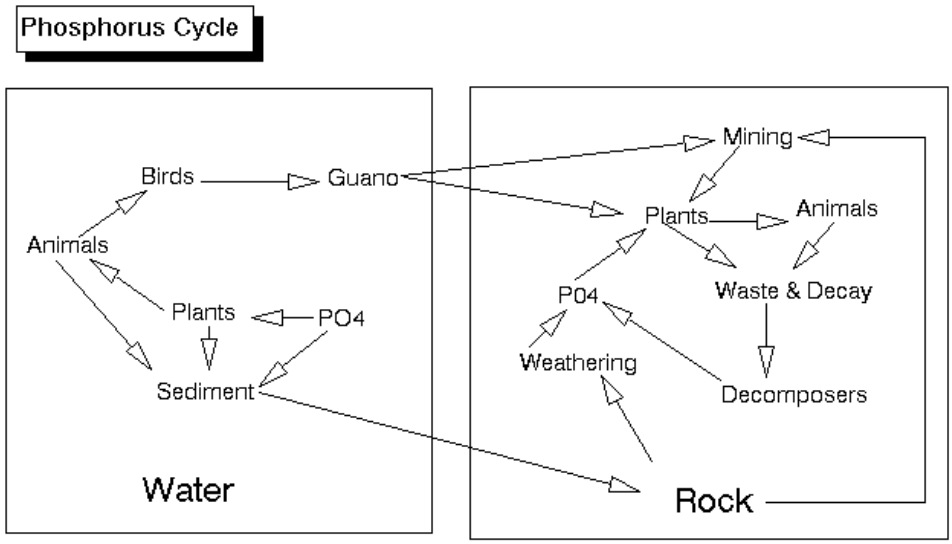
symbiotic, mutualistic associations with the roots of bean plants and other legumes (rhizobial bacteria); and the third form of nitrogen-fixing bacteria are the photosynthetic cyanobacteria (blue-green algae) which are found most commonly in water. All of these fix nitrogen, either in the form of nitrate or in the form of ammonia (nitrogen with 3 hydrogens attached). Most plants can take up nitrate and convert it to amino acids. Animals acquire all of their amino acids when they eat plants (or other animals). When plants or animals die (or release waste) the nitrogen is returned to the soil. The usual form of nitrogen returned to the soil in animal wastes or in the output of the decomposers, is ammonia. Ammonia is rather toxic, but, fortunately there are nitrite bacteria in the soil and in the water which take up ammonia and convert it to nitrite, which is nitrogen with two oxygens. Nitrite is also somewhat toxic, but another type of bacteria, nitrate bacteria, take nitrite and convert it to nitrate, which can be taken up by plants to continue the cycle. We now have a cycle set up in the soil (or water), but what returns nitrogen to the air? It turns out that there are denitrifying bacteria which take the nitrate and combine the nitrogen back into nitrogen gas.

The nitrogen cycle has some important practical considerations, as anyone who has ever set up a saltwater fish tank has found out. It takes several weeks to set up such a tank, because you must have sufficient numbers of nitrite and nitrate bacteria present to detoxify the ammonia produced by the fish and decomposers in the tank. Otherwise, the ammonia levels in the tank will build up and kill the fish. This is usually not a problem in freshwater tanks for two reasons. One, the pH in a freshwater tank is at a different level than in a saltwater tank. At the pH of a freshwater tank, ammonia is not as toxic. Second, there are more multicellular plant forms that can grow in freshwater, and these plants remove the ammonia from the water very efficiently. It is hard to get enough plants growing in a saltwater tank to detoxify the water in the same way.

**The Phosphorous Cycle.**

The phosphorous cycle is the simplest of the cycles that we will examine (I like to save the simplest for the last sometimes; it's like a cool-down period after a long run). For our purposes, phosphorous has only one form, phosphate, which is a phosphorous atom with 4 oxygen atoms. This heavy molecule never makes its way into the atmosphere, it is always part of an organism, dissolved in water, or in the form of rock. When rock with phosphate is exposed to water (especially water with a little acid in it), the rock is weathered out and goes into solution. Autotrophs take this phosphorous up and use it in a variety of ways. It is an important constituent of cell membranes, DNA, RNA, and, of course ATP, which, after all, stands for adenosine tri*phosphate*. Heterotrophs (animals) obtain their phosphorous from the plants they eat, although

one type of heterotroph, the fungi, excel at taking up phosphorous and may form mutualistic symbiotic relationships with plant roots. These relationships are called *mycorrhizae*; the plant gets phosphate from the fungus and gives the fungus sugars in return. Animals, by the way, may also use phosphorous as a component of bones, teeth and shells. When animals or plants die (or when animals defecate), the phosphate may be returned to the soil or water by the decomposers. There, it can be taken up by another plant and used again. This cycle will occur over and over until at last the phosphorous is lost at the bottom of the deepest parts of the ocean, where it becomes part of the sedimentary rocks forming there. Ultimately, this phosphorous will be released if the rock is brought to the surface and weathered. Two types of animals play a unique role in the phosphorous cycle. Humans often mine rock rich in phosphorous. For instance, in Florida, which was once sea floor, there are extensive phosphate mines. The phosphate is then used as fertilizer. This mining of phosphate and use of the phosphate as fertilizer greatly accelerates the phosphorous cycle and may cause local overabundance of phosphorous, particularly in coastal regions, at the mouths of rivers, and anyplace where there is a lot of sewage released into the water (the phosphate placed on crops finds its way into our stomachs and from there to our toilets). Local abundance of phosphate can cause overgrowth of algae in the water; the algae can use up all the oxygen in the water and kill other aquatic life. This is called eutrophication.




The other animals that play a unique role in the phosphorous cycle are marine birds. These birds take phosphorous containing fish out of the ocean and return to land, where they defecate. Their guano contains high levels of phosphorous and in this way marine birds return phosphorous from

the ocean to the land. The guano is often mined and may form the basis of the economy in some areas.

**Lecture No.: 05**

**Types of ecosystem**

| Types of Ecosystems: | Terrestrial Ecosystems | Aquatic Ecosystems |
|---|---|---|
| | Forest | Pond |
| | Grassland | Lake |
| | Semi arid areas | Wetland |
| | Deserts | River |
| | Mountains | Delta |
| | Islands | Marine |

Terrestrial ecosystems in their natural state are found in different types of forests, grasslands, semiarid areas, deserts and sea coasts. Where the land is intensively used, these have been gradually modified over several thousand years into agricultural and pastoral regions. In the recent past they have been rapidly converted into intensively irrigated agricultural ecosystems or into urban and industrial centers. Though this has increased production of food and provides the raw material for 'consumer' goods that we use, the overuse and misuse of land and natural ecosystems has led to a serious degradation of our environment. The unsustainable use of environmental goods such as soil, water, fuelwood, timber from forest, grasses and herbs from grasslands for grazing and repeatedly burning the grass, degrades these natural ecosystems. Similarly, improper use of resources can destroy the services that the natural ecosystems provide. These processes of nature such as photosynthesis, climate control, prevention of soil erosion are disturbed by many human activities. When our human population was small, most ecosystems could supply all our needs. Resources were thus used 'sustainably'. As industrial 'development' led to a very great increase in consumption of resources, the short term economic gains for people became an indicator of progress, rather than long term ecological benefits. This has resulted in an 'unsustainable use' of natural resources. Forests thus disappear, rivers run dry, deserts begin to spread, and air, water and soil become increasingly polluted as by-products of development. Human well being itself is then seriously affected.

**Forest ecosystem**

Forests are formed by a community of plants which is predominantly structurally defined by its trees, shrubs, climbers and ground cover. Natural vegetation looks vastly different from a group

of planted trees, which are in orderly rows. The most 'natural' undisturbed forests are located mainly in our National Parks and Wildlife Sanctuaries. The landscapes that make up various types of forests look very different from each other. Their distinctive appearance is a fascinating aspect of nature. Each forest type forms a habitat for a specific community of animals that are adapted to live in it.

**The forest ecosystem has two parts:**

- The non-living or abiotic aspects of the forest.
- The living or the biotic aspects of the forest

Forest types in India: The forest type depends upon the abiotic factors such as climate and soil characteristics of a region. Forests in India can be broadly divided into Coniferous forests and Broadleaved forests. They can also be classified according to the nature of their tree species – evergreen, deciduous, xerophytic or thorn trees, mangroves, etc. They can also be classified according to the most abundant species of trees such as Sal or Teak forests. In many cases a forest is named after the first three or four most abundant tree species.

In **aquatic ecosystems**, plants and animals live in water. These species are adapted to live in different types of aquatic habitats. The special abiotic features are its physical aspects such as the quality of the water, which includes its clarity, salinity, oxygen content and rate of flow. Aquatic ecosystems may be classified as being stagnant ecosystems, or running water ecosystems. The mud gravel or rocks that form the bed of the aquatic ecosystem alter its characteristics and influence its plant and animal species composition. The aquatic ecosystems are classified into freshwater, brackish and marine ecosystems, which are based on the salinity levels.

The fresh water ecosystems that have running water are streams and rivers. Ponds, tanks and lakes are ecosystems where water does not flow. Wetlands are special ecosystems in which the water level fluctuates dramatically in different seasons. They have expanses of shallow water with aquatic vegetation, which forms an ideal habitat for fish, crustacea and water birds.

Marine ecosystems are highly saline, while brackish areas have less saline water such as in river deltas. Coral reefs are very rich in species and are found in only a few shallow tropical seas. The richest coral reefs in India are around the Andaman and Nicobar islands and in the gulf of Kutch. Brackish water ecosystems in river deltas are covered by mangrove forests and are among the world's most productive ecosystems in terms of biomass production. The largest mangrove swamps are in the Sunderbans in the delta of the Ganges.

**Lecture No. : 06**

# Biodiversity

"Biodiversity" is often defined as the variety of all forms of life, from genes to species, through to the broad scale of ecosystems (for a list of variants on this simple definition see Gaston 1996). "Biodiversity" was coined as a contraction of "biological diversity" in 1985, but the new term arguably has taken on a meaning and import all its' own.

**Biological diversity - or biodiversity - is a term we use to describe the variety of life on Earth. It refers to the wide variety of ecosystems and living organisms: animals, plants, their habitats and their genes.**

Biodiversity is the foundation of life on Earth. It is crucial for the functioning of ecosystems which provide us with products and services without which we couldn't live. Oxygen, food, fresh water, fertile soil, medicines, shelter, protection from storms and floods, stable climate and recreation - all have their source in nature and healthy ecosystems. But biodiversity gives us much more than this. We depend on it for our security and health; it strongly affects our social relations and gives us freedom and choice.

Biodiversity is extremely complex, dynamic and varied like no other feature of the Earth. Its innumerable plants, animals and microbes physically and chemically unite the atmosphere (the mixture of gases around the Earth), geosphere (the solid part of the Earth), and hydrosphere (the Earth's water, ice and water vapour) into one environmental system which makes it possible for millions of species, including people, to exist.

At the same time, no other feature of the Earth has been so dramatically influenced by man's activities. By changing biodiversity, we strongly affect human well-being and the well-being of every other living creature.

**CLASSIFICATION OF BIODIVERSITY:** Biological diversity infers a richness of living forms or species that have developed usually over a long period of geological time and that are adapted to the wide array of ecological habitats that exist on earth. In our search to understand the natural world, to appreciate both scientifically and aesthetically the variety of life we see, it is necessary to note the basic characteristics of organisms and to decipher how those characteristics developed. In addition, knowledge of the taxonomic and phylogenetic relationships of organisms permits the construction of classification systems and provides information that is critical both in selective breeding programs and in determining which habitats should be set aside for preservation or conservation. In plants, as in animals and other groups, certain morphological characteristics tend to be 'conservative' in their expression that is, they do not vary when the organisms grow in different habitats. These 'conservative' characters are the ones that

taxonomists have used to define species and to construct classifications. Such characters are reliable and remain consistent from one generation to the next. Characters that vary in differing environmental conditions are not consistent or taxonomically useful in distinguishing different groups. In plants, reproductive characters tend to be more conservative than vegetative characters. The ordering of diversity into a recognizable pattern is the basis of any classification scheme. Studies of pre-European indigenous cultures have shown that there is a distinct correlation between the use of language and the ordering of organisms into a few accessible categories that are hierarchical in form. The sets within sets of all folk classifications likely reflect a real pattern in nature in which organisms show genealogical descent with modification. In modern-day systematics, we strive to construct classifications that are phylogenetic using numerous sources of data, such as morphological, molecular, reproductive, cytological, ecological, physiological, and chemical. Ideally, these classifications reflect the evolutionary history of groups of organisms that are monophyletic, that is, descended from a common ancestor.

In many cases, though, our data are not sufficient to identify monophyletic groups with certainty and the classification that results has to be treated as a hypothesis of phylogenetic relationships that can be tested in the future with new or additional characters or data. The categories, or ranks, in the hierarchy are applicable to all types of organisms and follow a given sequence. The principal categories are: kingdom, phylum (division is sometimes used in plants), class, order, family, genus, and species. If more categories are needed, they are intercalated between or added to the principal ones and are denoted by prefixes sub- or super- (as in subclass, subspecies, and superorder) or by the introduction of supplementary terms (e.g., section between genus and species or series between section and species). Infraspecific ranks that are used commonly are subspecies and variety. The rank or level of a category usually can be recognized by a standardized ending (e.g., -idae for subclass, -ales for order, - aceae for family [pronounced a, c, e]). The term taxon (taxa, plural) is used to refer to a taxonomic group of any rank. The scientific name for a species is an italicized binomial, consisting of both the generic name and the specific name or epithet. Each scientific name pertains to only one kind of organism. For example, Quercus garryana is the scientific name for garry oak. The name of a genus is one word, such as Quercus (the oaks), and can be used alone, whereas the name of any species must include the generic name and the species name, such as Quercus garryana. The generic name can be abbreviated to the first letter, when written, provided the meaning is clear (Q. garryana). The specific epithet garryana cannot be used for any other species of the genus Quercus, although it can be used in another genus for an entirely different organism. Certain epithets are commonly

used. For instance, you will find many different genera with a species name columbiana or linearis or virginiana.

Scientific names are always latinized and in the Roman alphabet and provide a means for communicating about specific organisms on a worldwide basis. The plant kingdom is distinguished from others in that plants are generally green and autotrophic (nutritionally independent). There are several groups of plants, but the one that we are interested in here is the group of vascular plants. Recent phylogenetic analyses indicate that this group is a monophyletic one. Vascular plants form special thick-walled cells, tracheids and vessels (xylem tissues), which transport water and dissolved nutrients throughout a plant. A vascular system provides considerable strength and support to organs and enables a plant, if genetically disposed, to achieve heights of several meters. Vascular plants include ferns and their allies, which reproduce by spores, and "gymnosperms" and angiosperms, which reproduce by seeds. Classifications of vascular plant families are in an active state of revision. New sources of data, particularly molecular data, have provided new insights that have led to rearrangements of genera and families within classification schemes. The placement of families within orders and the positioning of many orders within classifications remain controversial. Questions concerning vascular plant classifications can be resolved once sufficient new data can be obtained and used to interpret the relationships of the families, orders, and classes. In this course, you will be introduced to several common flowering plant families.

**Threats to biodiversity**:

The main factor currently driving biodiversity loss is habitat destruction—on land; in streams, rivers,

and lakes; and in the oceans. Human activities such as: deforestation; bottom trawling in the oceans; the damming and dredging of streams, rivers, and lakes; and the draining and degradation of wetlands, estuaries, and mangroves are responsible.

Other threats to biodiversity and to ecosystems include: the over-harvesting of plant and animal species; the introduction of non-native species; and pollution. Many types of human-caused pollution are a threat—the release of excessive amounts of nitrates and phosphates from sewage and agricultural run-off; persistent organic pollutants that can concentrate in food webs (and in our own tissues) and adversely affect hormonal and reproductive function; pharmaceuticals used by people and in livestock production that are toxic to wildlife; acid rain; heavy metals; herbicides and pesticides; and plastics.

Still further threats come from: excessive ultraviolet radiation from depletion of the stratospheric ozone layer that can damage the DNA and proteins of land-based, freshwater, and marine organisms; war and conflict that can result in habitat destruction, over-hunting, and pollution; and climate change.

**Biodiversity conservation**:

Biodiversity conservation is about saving life on Earth in all its forms and keeping natural ecosystems functioning and healthy. Conservation biology as a scientific discipline has grown enormously over the past few decades and has increased our awareness and understanding of the great extent to which humans depend on natural ecosystems and biodiversity.

Conserving biodiversity means ensuring that natural landscapes, with their array of ecosystems, are maintained, and that species, populations, genes, and the complex interactions between them, persist into the future. Biodiversity conservation relies on a number of disciplines working together, including ecology and other biological sciences, physical sciences, mathematics, and the social sciences such as economics, law, public policy and psychology.

The ways in which humans as a species relate to the natural world lie along an axis ranging from unthinking cruelty and destructiveness to complacent indifference to informed dependence to committed engagement, and the way people are distributed along this axis obviously has profound implications for its conservation. In particular, it means that the level of official financial support for conservation is much lower and less secure than funding for agriculture, including the conservation of agricultural biodiversity.

Attitudes to conservation by those not involved in it are an external consideration, which often takes the form of a constraint. This paper mainly concerns conceptual and practical issues within the domain of conservation which influence its effectiveness. It is based on a recent analysis of these issues by Jenkins (2002) .

Being “effective” is taken to mean “producing a desired effect”. In the context of biodiversity conservation it is often difficult to reach a consensus either on what desired effects or ends should be or how they should be produced. Jenkins [op. cit] provides some insight into the difficulty of reaching consensus with the following argument:

There may be broad agreement that the ultimate goal of conservation is to maintain as much as possible of the world’s existing biodiversity.

A convenient way of exploring the issue about conservation is to address three fundamental questions:

Why should we conserve biodiversity?

What, exactly, should we be conserving?

How should we conserve biodiversity?

Why should we conserve biodiversity?

This question has been at the root of conflicts over environmental and conservation issues since the earliest stirrings of the modern conservation movement. In the United States of the late nineteenth and early twentieth century, for example, differences in values were personified by John Muir, leader of the movement to preserve wilderness and elected as first president of the Sierra Club in May 1892, and Gifford Pinchot, described as America's first professional forester. Muir's relationship with the natural world was essentially a spiritual one. He claimed that the "demands and the discontents of modern American civilization… were so great and the rewards were so fraudulent that wilderness preserves were a spiritual and psychological necessity" (Turner, 1997, page 312). Pinchot on the other hand was a utilitarian. In his view: "The object of our forest policy is not to preserve forests because they are beautiful or wild or the habitat of wild animals; it is to ensure a steady supply of timber for human prosperity. Every other consideration is secondary. …no lands will be permanent reserves which can serve the people better in any other way." (Turner, 1997, page 323)

In the arguments that raged during the first decade of the twentieth century over plans to build a dam to provide water for San Francisco that would flood the Hetch Hetchy valley in California's Yosemite National Park, the two men were predictably on opposing sides, Muir vehemently against, Pinchot resolutely for.

During the latter part of the twentieth century environmental economists attempted to capture the spectrum of values attached to biodiversity with categories such as: direct use, indirect use, option, existence and bequest. In these terms, the most marked difference is between those who allocate a high existence (or existence and bequest) value to the components of biological diversity in principle and those who do not. Preservationists are those who believe that biological diversity has intrinsic value and should be conserved for its own sake to the maximum extent possible, regardless of whether any given component can be shown to produce tangible economic benefits. They are effectively giving priority to existence and bequest values. Utilitarians, like Gifford Pinchot, attach low existence value to the individual components of biodiversity and hold that it is only justifiable to expend serious effort in maintaining those that can be shown to produce tangible benefits for humans, or conversely, that conservation actions are only justified if they do not entail any appreciable costs.

Despite the efforts of environmental economists to articulate the different values that may motivate conservation, both academic opionion and current events suggest that the conflict of values over why biodiversity should or should not be conserved has not abated.

In terms of academic opinion, Norton (2000) expresses the view that: "Recent international discussions of biodiversity policy have established two points: there is growing international commitment to sustain and protect biodiversity; and there is little agreement regarding why this should be done. Thus, while a significant international consensus regarding policy has apparently emerged, this consensus is not grounded in a consensually accepted value theory to explain why biodiversity protection, however strongly supported, should be a top priority of environmental policy."

Firstly, it is obvious that in the modern world with its growing population, rising material aspirations and increasing appetite for energy and other critical resources, almost any substantial tract of land may attract the interest of a diversity of constituencies, which could include environmentalists, developers, international donors, national government departments and officials, civil society, local residents and communities, and so on. It is surely necessary for all these constituencies to recognize the legitimate interests of other stakeholders and to make what concessions they can without compromising their own needs, rights and principles.

Secondly and more tentatively, there seems to be some scope in such situations of conflict for deploying the expertise in decision analysis that has been developed over more than half a century, mainly in relation to business management but also in relation to thinking about values (e.g. Keeney 1994). Finding new ways of understanding and articulating old problems and exploring alternative solutions in ways that are rigorous and systematic but also imaginative, could reveal ways of reconciling seemingly conflicting interests.

What, exactly, should we be conserving?

The Convention on Biological Diversity (CBD) has been ratified by more than 180 states and can thus be taken to represent, at least nominally, the views of the vast majority of the world's governments. The CBD, along with others (e.g. Mangel et al., 1996), in effect advocates conservation of genes, species and ecosytems, but it is rarely, if ever, a practical possibility to operate at all three levels, so decisions still have to be made about which aspects of biological diversity deserve priority. There is little consensus on this, and the absence of authoritative and usable guidance on what exactly we should be conserving has led to a diversity of approaches to the question of how biodiversity can best be conserved (e.g. IUCN, 1994, Noss, 1996 at page 574, Janzen, 1998, Angemeier 2000, Parks Canada, 2000, Myers et al., 2000).

How should we conserve biodiversity?

If one examines existing practice in terms of the genes, species and ecosystems approach it becomes evident that the influence of the CBD is as yet rather limited. Conservation of genetic resources, in the sense of intra-specific genetic diversity, is seldom a feasible activity in field-based work, but it is a central concern in captive breeding projects and is also a consideration in

reintroduction projects. Since it is clearly impossible to conserve all species, decisions have to be made about what species to prioritize. There are two different approaches: one that concentrates on identifying individual species of importance, and one that identifies important areas where it is hoped that actions will benefit a significant number of species.

**SPECIES-BASED CONSERVATION**

There is no global consensus as to what constitutes an important species, but species may be singled out for conservation action if they fall into one or more of the following categories:

Threatened species

Ecologically important species

Species useful to humans

Species with non-use value.

**Threatened species**

Threatened species are those that are believed to be in danger of extinction. Threatened species listing systems, such as the US Endangered Species Act and the IUCN system, give clear guidance as to which species are believed in most urgent need of conservation action. But the guidance is incomplete because only a small proportion of the world's species has yet been assessed in terms of extinction risk. Information is most complete for birds and mammals and is very incomplete in most invertebrate and plant groups.

It is widely agreed that it is unrealistic at present to expect concerted conservation efforts to be undertaken for each of these threatened species individually, but there is not much agreement on which threatened species are most deserving of attention. For example, it is often assumed that the most threatened species are those that should be accorded highest priority and should therefore be the principal focus of action. But it can also be argued that some of these species are lost causes and that resources are better spent elsewhere.

**Ecologically important species**

It can be inferred from basic ecological understanding that keystone species which play a crucial role in ecosystems should be considered to be a high priority for conservation, and the thinking of ecologists is being vindicated by the results of so-called ‘small world’ analyses.

“The true keysones in an ecological community are the most highly connected species, the hubs of the network. The keystones are the ecological control centres, so to speak, and clearly the most important targets for preservation.” (Buchanan, 2002, page 154). But there are no rules for determining which are likely to be the keystone species, so identifying them can be difficult and demanding.

**Species useful to humans**

These include wild species that are harvested for food, medicines, clothing, building materials or other purposes, wild relatives of domesticated species or wild species (chiefly bacteria) with biochemical attributes that can potentially be harnessed industrially. In addition, some species are subject to non-consumptive use that can be expressed in economic terms. These are chiefly species that play an important role in tourism.

**Species with non-use values**

A number of species have an importance that cannot easily be quantified in economic terms. That is, a significant number of stakeholders ascribe a non-trivial existence or bequest value to them. Globally, the most important of these are the so-called “charismatic” species, particularly the charismatic megafauna, including large carnivores and birds of prey, cetaceans, sea-turtles, elephants, rhinoceroses and the great apes, but also some groups of smaller species such as other primates, parrots, large butterflies, and even some plants. Species may also be important for religious, spiritual or scientific reasons.

And of course, a species may be important for more than one reason. For example, the Malagasy Indri (Indri indri) is regarded as a sacred species by local people in much of its range, is decidedly charismatic, with great popular appeal, and is of considerable scientific interest to primatologists (Harcourt, 1990).

With so many reasons for attaching importance to species, it is not surprising that there is litte agreement on which species merit special conservation action. Local priorities may be different from national ones, which may in turn be different from global ones. For example, a species that is considered of high priority by some biologists because it is both taxonomically distinct and threatened, may be of little interest or concern to local people within its range. Conversely, a population of a widespread, non-threatened species regarded by conservation biologists as of low priority internationally may be of considerable local importance.

## AREA-BASED CONSERVATION

Area-based approaches are widely advocated for planning in species’ conservation. They are based on the observation that some parts of the world have far more species than others. Areas with large numbers of species, especially endemics, are often referred to as "hotspots" (Myers et al., 2000). It is argued that by concentrating conservation efforts in these areas, a disproportionate impact can be had on the maintenance of global biological diversity. This approach can theoretically be applied at any geographical scale. It is widely accepted that such area-based approaches are the only realistic hope of maintaining a significant proportion of the

world's biological diversity, but there are both practical and theoretical difficulties in identifying the most important areas.

On problem is that information on global species' distribution is very incomplete and heavily biased towards large, conspicuous forms, so identification of important areas has to be made on the basis of partial knowledge and is usually based on an assumption that areas important for well-known species are also important for others, that is that measures of diversity in different groups of organisms are highly correlated, but this may not necessarily be the case. A further difficulty is that species' diversity may be important either for its richness or for its endemicity. There is notway of judging the relative importance of an area with high species' richness but low endemicity against an area with lower species'richness but higher endemicity.

Much also depends on the scale at which any assessment is made: a square metre of European chalk grassland will contain many more plant species than a square metre of tropical moist forest, while for an area of one square kilometre the reverse will be the case.

Concentration of conservation efforts on global hotspots of species' richness and endemism, assuming that these can be reliably identified, has a number of implications. Most importantly, it implicitly ignores the large part of the world that is not within a hotspot, and the high proportion of species not present in such areas. It therefore embodies what is ultimately a narrow conception of global conservation priorities.

The ecoregion approach avoids the problem associated with hotspot methods, of recognizing only a limited set of areas as of conservation importance. It combines analysis of biogeography, based on the distributions of species and species' groups, particularly narrow endemics, with an assessment of the dominant natural ecosystem or ecosystems in a particular area to divide the world, or part of the world, into a series of ecoregions. The identified conservation goal is then to maintain representative samples of natural areas in each of the identified ecoregions, or in those identified as of high priority because of their uniqueness or the urgency or scale of the threats they face.

But the ecoregion approach is based on the assumption that the world can usefully be divided into discrete, identifiable regions of this kind, and that these regions are suitable units for conservation planning. Both these assumptions are to some degree problematic. In the first instance, natural habitats and ecosystems seem generally to form part of a highly variable continuum, unless they are separated by very definite physical barriers, rather than form discrete entities. Dividing this continuum into units is to some extent therefore an artificial exercise. In addition, biogeographic patterns in different groups of organisms are not necessarily highly correlated with each other. Thus, a biogeographic analysis using vascular plant families will yield a different set of patterns from one using vertebrate families. Similarly, ecoregional

classifications based on terrestrial ecosystems and biota have limited relevance, at least in continental regions, to freshwater systems where biogeography is very largely determined by drainage patterns.

**ECOSYSTEM APPROACHES**

The Parties to the Convention on Biological Diversity have decided that the ecosystem approach should be the primary focus for actions undertaken to meet the objectives of the convention. They have subsequently devoted some effort to deciding what this actually means in practice. There appear to be two separate, though linked, concepts involved here. The first is the maintenance of particular ecosystems of importance. Implicit in this is the assumption that such ecosystems can be considered to be spatially distinct entities, so that this involves conservation of particular more or less well-defined areas. The second is the maintenance of ecosystem processes.

The CBD itself recognizes the following ecosystems and habitats as of importance (Annex I of the Convention). Those containing high diversity, large numbers of endemic or threatened species, or wilderness; required by migratory species; of social, economic, cultural or scientific importance; or, which are representative, unique or associated with key evolutionary or other biological processes. It further defines an ecosystem as "a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit". Several of the categories of importance that are defined implicitly or explicitly with reference to species are effectively reformulations of the area-based approaches to species' conservation outlined above.

An alternative approach to conservation emphasizes natural processes rather than the particular entities (populations of various species) that mediate these processes. At the most fundamental level, these processes are energy fixation (almost entirely through photosynthesis), the cycling of that energy and of a range of organic and inorganic chemicals. They also include regulation of climate and water movement on land, soil formation and retention and, in the sea, formation of reefs and other zoogenic structures. These processes take place across all spatial and temporal scales.

Maintenance of these processes is seen as important for three main reasons. The first is to allow ecosystems to continue providing goods and services to humans; the second is to maintain or restore naturalness; the third is as a means of allowing populations of species to be maintained, or rather to maintain themselves. This last case can be seen as essentially a methodology for organism or species-based conservation, discussed above.

**Lecture No: 07**

# Environmental pollution

Pollution may be defined as an undesirable change in the physical, chemical or biological characteristics of air, water and land that may be harmful to human life and other animals, living conditions, industrial processes and cultural assets. Pollution can be natural or manmade. The agents that pollute are called pollutants.

**Pollutants**

Pollutants are by-products of man's action. The important pollutants are summarised below:

• **Deposited matter—**Soot, smoke, tar or dust and domestic wastes.

• **Gases—**CO, nitrogen oxides, sulphur oxides, halogens (chlorine, bromine and iodine).

• **Metals—**Lead, zinc, iron and chromium.

• **Industrial pollutants—**Benzene, ether, acetic acid etc., and cyanide compounds.

• **Agriculture pollutants—**Pesticides, herbicides, fungicides and fertilizers.

• **Photochemical pollutants—**Ozone, oxides of nitrogen, aldehydes, ethylene, photochemical smog and proxy acetyl nitrate.

• **Radiation pollutants—**Radioactive substances and radioactive fall-outs of the nuclear test.

**Classification of Pollutants**

On the basis of natural disposal, pollutants are of two types:

(i) Non-degradable pollutants

These are the pollutants, which degrade at a very slow pace by the natural biological processes. These are inorganic compounds such as salts (chlorides), metallic oxides waste producing materials and materials like, aluminium cans, mercuric salts and even DDT. These continue to accumulate in the environment.

(ii) Biodegradable pollutants

These include domestic sewage that easily decomposes under natural processes and can be rapidly decomposed by natural/ artificial methods. These cause serious problems when accumulated in large amounts as the pace of deposition exceeds the pace of decomposition of disposal. On the basis of the form in which they persist after their release into the environment, pollutants can be categorized under two types:

*(i)* **Primary pollutants:** These include those substances, which are emitted directly from some identifiable sources. This include-

*(a) Sulphur compounds:* $SO_2$, $SO_3$, $H_2S$ produced by the oxidation of fuel.

(*b*) *Carbon compounds:* Oxides of carbon ($CO+CO_2$) and hydrocarbons.

(*c*) *Nitrogen compounds:* $NO_2$ and $NH_3$.

(*d*) *Halogen compounds:* Hydrogen fluoride (HF) and hydrochloric acid (HCl).

(*e*) *Particles of different size and substances:* These are found suspended in air. The fine particles below the diameter of 100u are more abundant and include particles of metals, carbon, tar, pollen, fungi, bacteria, silicates and others.

(*ii*) **Secondary pollutants.** The secondary pollutants are produced by the combination of primary emitted pollutants. in the atmosphere. In bright sunlight, a photochemical reaction occurs between nitrogen oxides; oxygen and waste hydrocarbons from gasoline that forms peroxyacetyle nitrate (PAN) and ozone (O3), Both of them are toxic components of smog and cause smarting eyes and lung damage.

(*iii*) **Smog.** The fog deposited with smoke and chemical fumes forms a dark and thick covering, the smog. Smog is very common in almost all the industrial areas as the smog is trapped for many days by the stagnant air. It is harmful both for animals and plants.

**Air Pollution**

The WHO defines **air pollution** as the presence of materials in the air in such concentration which are harmful to man and his environment. A number of ingredients find their way in the air and these are mostly gases, which rapidly spread over wide areas.

**Sources**

Various sources of air pollution are fossil fuels, industries, agricultural activities, wars, natural causes arid emissions from vehicles.

**(i) Burning Fossil Fuels**

Burning of wood, charcoal and other fossil fuels causes air pollution by the release of carbon dioxide (CO2), carbon sulphur dioxide etc. Petroleum consists mainly of hydrocarbons, sulphur and nitrogen.

**(ii) Emissions from Automobiles**

Vehicles are mainly responsible for more than 80% of total air pollution. The major pollutants released from automobiles, locomotives, aircraft etc., include CO, unburnt hydrocarbons and nitrogen oxide.

**(iii) Industries**

Paper and pulpfactories, petroleum refineries, fertilizer plants, and steel industries, thermal power plants are the main sources of air pollution. They add various harmful gases like CO, SO3, NO, Hydrocarbons etc., to the atmosphere. Textile factories release cotton dust into the air. Cities experiencing this type of pollution are Kanpur, Surat and Ahmedabad. The pesticide and

insecticide industries are posing serious threat to the environment. Food processing industries and tanneries emit offensive odors. Release of poisonous gases from
accidents also poses serious threats. e.g. Bhopal Gas Tragedy in which methyl isocynate (MIC) gas leakage killed several people. In Tokyo, about 34 tones of carbon particles mixed with other suspended particles settle per square kilometer every day.

**(iv) Agricultural Activities**

Spraying of insecticides and weedicides also cause air pollution. These, when inhaled create severe problems to both animals and man.

**(v) Wars**

Various forms of explosives used in war pollute the air by releasing poisonous gases. This greatly disturbs the ecology of the area. Nuclear explosions pollute air by radioactive rays. The effects of nuclear explosions on Hiroshima and Nagasaki are well-known examples.

**(vi) Natural Causes**

Gas emissions from active volcanoes, marsh gas, spores of fungi and pollens are the natural causes of air pollution.

**COMMON AIR POLLUTANTS**

Air pollutants are of two main types ~gaseous and particulate. Oxides of carbon. Nitrogen and sulphur are gaseous pollutants. Particulate pollutants may be solid or liquid particles, larger particles settle down quickly viz., sand and water droplets whereas small dust particles remain suspended in air for a long time. These are added into the atmosphere by the
processes of blasting, drilling, crushing, grinding and mixing.

**(i) Carbon Dioxide**

CO2 content of air has increased by 20% during the last century. CO2 causes nausea and headache. It's increase in the air may cause green house effect, rise in the atmospheric temperature. This may melt the polar ice resulting in rise in level of oceans and flooding of coastal regions.

**(ii) Carbon Monoxide**

It is a very poisonous gas and is produced by incomplete combustion of fuel. If inhaled it combines with hemoglobin and reduces its oxygen-carrying capacity. This leads to laziness, reduced vision and death.

**(iii) Oxides of Nitrogen**

These include NO and NO2, which are released by automobiles and chemical industries as waste gases and also by burning of materials. These are harmful and lower the oxygencarrying capacity of blood.

**(iv) Oxides of Sulphur**

SO2 and SO3 are produced by burning of coal and petroleum and are harmful to buildings, clothing, plants and animals. High concentration of SO2 causes chlorosis (yellowing of leaves), plasmolysis, damage to mucous membrane and metabolic inhibition. SO2 and SO3 react with water to form Sulphuric and sulphurous acids. These may precipitate as rain or snow producing acid rain or acid precipitation.

**(v) Photochemical Oxidants**

Formed by the photochemical reactions between primary pollutants, viz. oxides of nitrogen and hydrocarbons. Nitrogen oxides in the presence of sunlight react with unburnt hydrocarbons to form peroxyacyl nitrate (PAN), Ozone, aldehydes and some other complex organic compounds in the air.

**(vi) Hydrocarbons**

These are unburnt discharges from incomplete combustion of fuel in automobiles. These form PAN with nitrogen oxides, which is highly toxic.

**(vii) Particulate Matter**

Industries and automobiles release fine solid and liquid particles into the air. Fly ash and soot from burning of coal, metal dust containing lead, chromium, nickel, cadmium, zinc and mercury from metallurgical processes; cotton dust from textile mills; and pesticides sprayed on crops are examples of particulate pollutants in the air. These are injurious to respiratory tract.

**(viii) Aerosols**

Aerosols are chemicals released in the air in vapour form. These include fluorocarbon (carbon compound having fluorine) present in emissions from the Jet aeroplanes. Aerosols deplete the ozone layer. Thinning of ozone layer results in more harmful ultraviolet rays reaching the earth, which are harmful to skin, and can lead to skin cancer also.

**(ix) Radioactive Substances**

These are released by nuclear explosions and explosives. These are extremely harmful for health.

**(x) Fluorides**

Rocks, soils and. minerals containing fluorides release an extremely toxic gas called hydrogen fluoride on heating. This gas is highly injurious to livestock and cattle.

**POLLUTION IN INDIA**

India supports a large network of factories and industries. These factories are generally localized in eight or ten large industrial centres. These are also a great source of air as well water pollution. To be on a safer side delocalisation of industries is the need of the time. This would lead to an even distribution of pollutants and faster degeneration of pollutants.

The major pollutants coming out from these industries are -

*(i) Industrial Pollutants.* The common air pollutants from industries are SO2, CO, CO2, H2S and hydrocarbons together with dust, smoke and grit. These are produced by the burning of coal and petroleum and by the combustion of lignite at thermal power stations. The chemical industries release HCl, chlorine, nitrogen oxide and oxides of copper, zinc, lead and arsenic. The fertilizer factories at Gorakhpur and Ahmedabad; the steel industries at Bhilai, Rourkela, Jamshedpur and Durgapur pollute the air with above-said gases.

*(ii) Automobile Exhausts.* Automobiles run by petrol and diesel produce CO, nitrogen oxides and hydrocarbons. Hundreds and thousands tons of hydrocarbons and CO are emitted into air daily. Metropolitan cities harbour lakhs and crores of

automobiles. Every gallon of petrol consumed by automobiles produces 3 pounds of carbon monoxide and 15 pounds. of nitrogen oxide.

*(iii) Ionizing Radiations from Radioactive Substances.* Ionizing radiations include alpha, beta particles and the gamma rays etc. These are produced by atomic explosions and testing of atomic weapons.

**Effects of Air Pollution**

Effect on Plants

(*i*) SO2 causes chlorosis and also results in the death of cells and tissues.

(*ii*) Fluorides and PAN damage leafy vegetables such as lettuce and spinach.

(*iii*) Oxides of nitrogen and fluorides reduce crop yield.

(*iv*) Smog bleaches and blaze foliage of important leafy plants.

(*v*) Hydrocarbons cause premature yellowing, fall of leave and flower buds, discoloration and curling of sepals and petals.

(*vi*) Smoke and dust cover the leaf surface and reduce photosynthetic capacity of plants.

(*vii*) Ozone damages cereals, fruits, and cotton crop.

Effect on Man

The effect of pollutants on animals and man are as follows-

*(i*) Ozone causes dryness of mucous membranes, changes eye vision, causes headache, pulmonary congestion and oedema.

(*ii*) Ozone has been reported to produce chromosomal aberrations.

(*iii*) SO2 causes drying of mouth, scratchy throat, smarting eyes and disorders of respiratory tract.

(*iv*) SO3, CO and NO2 diffuse into blood stream and reduce oxygen transport. CO damages cardiovascular system. Hydrocarbons and other pollutants act, as carcinogens and lead to different cancers.

(*v*) Cotton dust leads to respiratory disorders *e.g.* bronchitis and asthma.

(*vi*) Smoking of tobacco causes cancerous growth in lungs.

**Control of Air Pollution**

Following measures have been suggested to control air pollution-

(*i*) Some gases, which are more soluble in a particular liquid than air, for example, ammonia in water, can be separated by dissolving in it

(*ii*) Particles larger than 50 mm are separated in gravity settling tanks. Using cyclone collectors or electrostatic precipitators separates fine particles.

(*iii*) The height of chimneys should .be increased to the highest possible level to reduce pollution at the ground level.

(*iv*) SO2 pollution can be controlled by extracting sulphur from the fuel before use.

(*v*) Pollution control laws should be enforced strictly.

(*vi*) Trees should be planted on the roadside, riverbanks, parks and' open places as they keep the environment fresh.

(*vii*) Population growth, which is the main cause of pollution should be checked.

(*viii*) Nuclear explosions should be restricted.

**Water Pollution**

Water is extremely essential for life, this common fact is known to all. It is required to meet our basic needs in day to day life viz., cooking, drinking, bathing, disposal of sewage, irrigation, generating electricity in power plants, cooling and manufacturing different products in industries and the disposal of industrial wastes. During all these processes the undesirable substances are added to the water resources to a great extent. This alters the basic chemistry of water in rivers and streams.

**Sources of Water Pollution**

(i) Domestic sewage

This includes household's wastes like food wastes, synthetic detergents used for washing clothes and cleaning bathrooms and latrines and water based paints.

(ii) Industrial effluents

The industrial wastes are discharged in the adjoining rivers and streams through flush lines of factories. The textiles, sugar and fertilizers factories, oil refineries, drugs manufacture, rubber, and rayon fibers, the paper industries and the chemical factories all produce Chemical pollution.

(iii) Agricultural source

Increased use of fertilizers has become essential for high yielding crop plants. Excess of nitrates used as fertilizers seep into ground water is carried into lakes and pond. On entering the drinking water supply system these create several health problems.

(iv) Pesticides

These include insecticides, fungicides, nematicides, rodenticides, herbicides and soil fumigants. These contain chlorinated hydrocarbons, organophosphates, metallic salts, carbonates, acetic acid derivatives etc. many pesticides are non-degradable. They pass through the food chains and accumulate in fatty tissues thus causing several health hazards.

(v) Thermal pollution

Power plants and nuclear power stations are the main sources of thermal pollution of water where water is used for cooling and becomes hot. The hot water on entering the main water body raises its temperature, which kills fishes and other aquatic animals and increases the rate of respiration in aquatic plants.

(vi) Pathogenic organisms

Sewage and domestic waste from houses introduces pathogenic organisms viz., protozoa, worms-eggs and bacteria into water. This contaminated water if consumed causes jaundice, typhoid, dysentery, cholera, tuberculosis etc.

(vii) Mineral oils

Oil from oil spills and washings of automobiles finds way into river water through sewers.

(viii) Underground water pollution

Underground water particularly in cities and industrial areas is no more pure and safe. The sources of underground water pollution are sewage, seepage, pits, industrial effluents, septic tanks, fertilizers and pesticides, garbage etc.

(ix) Marine water pollution

River and stream network sources of water ultimately end up ocean and seas. Thus, these acts as the sink of all natural and man-made water based pollutants. The main sources of oceanic pollution are discharges of oil, greases, petroleum products, detergents, sewage and garbage including radioactive wastes.

**Effect of Water Pollutants**

The main effects of water pollutants are:

1. Compounds of mercury, arsenic and lead are poisonous and chemically harmful as they even affect water treatment plants e.g. organic sulphur compounds interfere with nitrification.

2. Mercury when dissolved in water is absorbed by aquatic plants and enters the food chain. Lead impairs metabolism and brings about congenital deformities, anaemia etc.

3. Cadmium damages kidneys and liver.

4. Inorganic nitrates and phosphates promote growth of oxygen-consuming algae, which result in the death of fishes and other aquatic animals.

5. Presence of dyes and compounds in the discharged water changes the colour of water.

6. Soap, detergents and, alkalis result in foam formation.

7. Industrial effluents containing iron, free chlorine, phenol, manganese, oils, hydrocarbons, ammonia, algae and microorganisms impair the taste and odours of water.

8. The nitrates and phosphates dissolved in water accelerate the growth of microorganisms, which consume much of the dissolved oxygen depriving fish and other aquatic life (Eutrophication).

9. Biomagnifications is the increase of toxic materials at each tropic level of a food chain. For example, DDT after reaching a water system is absorbed by the microorganisms on which smaller fishes feed. From them, DDT reaches the carnivorous animals. Since bigger fishes consume more food, large amounts of DDT accumulates in their body.

**CONTROL OF WATER POLLUTION**

(*i*) Separate ponds and tanks to be used for cattle and animals.

(*ii*) Use of pesticides, insecticides and fertilizers should be done judiciously. Rapid biodegradable substitutes for pesticides should be employed.

(*iii*) In towns where sewage facilities are not available, septic tanks should be made in the houses.

(*iv*) Rivers and lakes should not be used for bathing or washing as it contaminates water. .

(*v*) Domestic sewage and industrial wastes should be treated before discharging them into drains.

**Treatment of waste Water**

Domestic sewage and industrial wastes should be properly treated before these are drained in the mainstream water. Treatment involves the following two steps:

(i) Sewage treatment

It involves following steps:

*Primary treatment.* It involves physical processing of sedimentation, flotation and filtration where sewage water is passed through screens to remove larger particles and then through grinding mechanism to reduce the larger particles to smaller size. The sewage is finally passed through settling tanks to remove suspended impurities.

*Secondary treatment.* Sewage obtained after primary treatment is sent to aeration tank where it is mixed with air and sludge laden with bacteria and algae. The algae provide oxygen to the

bacteria and decompose organic matter into simple compounds. Chlorination is finally done to remove bacteria.

*Tertiary treatment.* In the third and last step water is passed through ion exchangers to remove dissolved salts.

(ii) Treatment of industrial effluents

Treatment of industrial effluents involves neutralization of acids and bases, removal of toxic compounds, coagulation of colloidal impurities, precipitation of metallic compounds and reducing the temperature of effluents to decrease thermal pollution.

**Marine Pollution**

All river drainages end up in the seas. On the way to sea, rivers carry large amounts of sewage, garbage, and agricultural discharge, biocides, including heavy metals. Besides this discharge of oils and petroleum products and dumping of radionuclides waste into sea also cause marine pollution. Huge quantity of plastic is being added to sea and oceans. Over

50 million lb plastic packing material is being dumped in sea of commercial fleets. Many marine birds ingest plastic that causes gastro-intestinal disorders. The chemical principle in PCBs causes more damage as thinning of eggshell and tissue damage of egg. Radionuclide waste in sea includes Sr-90, Cs-137, Pu-239, and And Pu-240. The pollutants in sea may become dispersed by turbulence and ocean currents and finally becomes a part of food chain. Bioaccumulation in food chain may result into loss of species diversity. The pollution in Baltic sea along the coast of Finland, took place largely

from sewage and effluents from wood industries. This pollution effect brought changes. In species diversity in the bottom fauna. In less polluted water there was rich species diversity, which tended to decrease with increasing pollution load. In heavily polluted areas, macroscopic benthic animals were absent, but chirognomy larvae occurred at the bottom. In marine

water the most serious pollutant is oil. Spill of oil or petroleum products due to accidents/ deliberate discharge of oil polluted waste brings about pollution. About 285 million gallons of oil are spilled each year into ocean, mostly from transport tankers. Oil pollution causes damage to marine fauna and flora including algae, fish, birds, and invertebrates. About 50,000 to 2,50,000 birds are killed every year by oil. The oil is soaked in feathers, displacing the air and thus interferes with buoyancy and maintenance of body temperature. Hydrocarbons and benzpyrene accumulate in food chain and consumption of fish by man may cause cancer. Detergents used to clean up the spill are also harmful to marine life.

**SOIL POLLUTION**

**Soil Pollution**

Like water and air, soil is also equally important for living organisms. It supports plants on which. all other living organisms depend. The process of soil formation is so slow that the soil may be regarded as a non-renewable source. Therefore, the study and control of soil pollution is important. Any substance that reduces soil productivity is called **soil pollutant.**

**Sources of Soil Pollution**

There are several materials, which adversely affect physical, chemical and biological properties of the soil and thus reduce its productivity. These are

1. Chemicals present in industrial waste.
2. Pesticides and insecticides that are sprayed on crops. .
3. Fertilizers and manures that are added to the soil to increase the crop yield.

**Effect of Soil Pollutants**

Chemicals and pesticides affect the structure and fertility of soil by killing the soil microorganisms. Pesticides are absorbed by the plants and then transferred to other organism. Hence, they affected food chains and food webs. Excretory products of livestock and human beings used as manure pollute the soil besides giving high yield. The faulty sanitation and unhygienic practices of the people add to the soil pollution. Pathogens present in the wastes and excreta contaminate the soil and vegetable crops causing diseases in man and domesticated animals.

**Types of Soil Pollution**

It is of the following types-

(i) Positive soil pollution

Reduction in the productivity of soil due to the addition of undesirable substances like pesticides, herbicides, fertilisers, etc. is called positive pollution. These pollutants have cumulative effect and kill the soil organisms.

(ii) Negative soil pollution

It is caused by the removal 01 useful components from soil by erosion, deforestation and improper methods of agriculture.

**Salination of Soil**

Increase in the concentration of soluble salts is called **salination**. This adversely affects the quality and productivity of soil. It takes place in two ways: accumulation of salts dissolved in

irrigation water on the soil surface due to intensive farming and poor drainage, and deposition of salts as white crust during summer months drawn by capillary action from the
lower surface to the top surface.

**Control of Soil Pollution**

Various measure to control soil pollution are-

1. Transfer stations for bulk shifting of refuse should be constructed in cities and big towns.
2. Pneumatic pipes should be laid for collecting and disposing wastes.
3. Materials like paper, glass and plastics can be recycled.
4. Metals should be recovered from scrap and disposed materials.
5. Use of chemical fertilizers should be reduced by the use of bio fertilizers and manures.
6. Use of pesticides can be reduced by adopting biological control of pests.
7. Use of cattle dung and agricultural wastes in biogas plants should be encouraged.
8. Deforestation can check soil erosion to a great extent.

**Land Degradation**

Besides pollution, land and soil face several other problems. Removal of topsoil is called soil erosion. Soil erosion factors are water, wind, ocean, waves and glaciers, felling of trees, overgrazing by cattle, over-cropping etc. Erosion occurs both in wet and dry regions. It leads to floods.

**Soil Erosion in India**

Soil erosion is a worldwide phenomenon, but it is especially high in Central Africa, China, India, Nepal, Australia, Spain, USA and USSR. India loses about 40,000 hectares of land every year as an effect of wind and water erosion. Damage to the topsoil is 18.5% of the total world's loss. This is due to overgrazing by livestock. The population of livestock in
India is the highest in the world. Overgrazing damages the topsoil, which reduces soil fertility.

(i) Deforestation of overgrazing

Over-grazing is the main cause of soil erosion in India. Roots of grasses act as binding material and keep the soil intact, which upon grazing are destroyed.

(ii) Desertification

Loss of soil productivity by erosion of top soil results in the formation of deserts. Deserts are spreading in all continents. Desertification takes place by shifting of sand dunes by wind and .over-grazing. That desert in India is spreading at the rate of 12,000 hectares of land every year.

(iii) Shifting cultivation

Tribal communities follow the practice of cutting down trees and setting them on fire and then raising the crops on the resulting ash. This is called *Jhuming* in northeastern India. It is harmful

if the Jhuming cycles are longer than ten years but short cycles destroy forests and cause soil erosion. e.g. Asia and Africa. .

(iv) Developmental activities

Large areas of fertile and productive croplands, woodlands and grasslands are lost to various developmental activities such as rapid urbanization, building of airports, industries, railways, roads, mining and construction of dams.

**Control of Land Degradation**

Following ways can control Land degradation

1. Restoration of forests and grass cover can help in prevention of soil erosion and floods.
2. By replacing shifting cultivation with crop rotation, mixed cropping or plantation cropping. Providing adequate drainage to irrigated and flood-prone lands can prevent salinity.
3. Desertification can be controlled by spread of appropriate plant species and by raising trees as wind breaks.

**Noise Pollution**

Noise can be defined as unwanted/unpleasant sound. So noise pollution is unwanted sound dumped into the atmosphere without regard to the adverse effects it may have. In our country urbanization and industrialization have become twin problems. Cities and towns have sprouted up where industries are concentrated. Lack of town' planning had led to

residential, commercial and industrial areas being mixed up. Houses, schools and hospitals are situated near industries. All the boons of industrialization and civilization such as motors, horns, heavy and light machinery, work and movement, blaring radios, supersonic aeroplanes have become disturbing and irritant. Our ears can hear ordinary conversation

between 30-60 decibels. Modern conversation has a noise value of 60 decibels. A decibel value greater than 80 decibels causes noise pollution. Noise becomes troublesome above 140 decibels.

**Effect of Noise Pollution**

1. Constant noise affects a man physically and mentally. Physical effects include blood vessels to contract, skin to become pale, muscles to constrict and rise in blood pressure leading to tension and nervousness.
2. High intensity sound emitted by industrial plants, bottling machines, supersonic aircrafts, when continued for long periods of time not only disturbs but also permanently damages hearing.
3. Offices, industries and crowded places where constant noise prevails can produce temper tantrums, headaches, fatigue and nausea.
4. Loud and sudden noise affect the brain. Intermittent noise leads higher incidence of psychiatric illness and also a danger to health of pregnant mothers and small infants.

5. Noise has harmful effects on nonliving materials too, *e.g.* cracks develop under the stress of explosive sound.

**Control of Noise Pollution**

Following methods can control noise pollution:

1. Limited use of loudspeakers and amplifiers.
2. Excursing control over noise producing vehicles.
3. Industrial workers should be provided with ear plugs.
4. Delocalisation of noisy industries far away from dwelling units.
5. Within a radius of 10 miles of airport, no buildings or factories should be allowed.
6. Plants and trees should be planted all around the hospitals, libraries and schools and colleges.
7. Personal protection against noise can be taken by using, cotton plugs in the ear.

**Role of an Individual in Prevention of Pollution**

Which are the most viable, efficient and economical ways to eliminate pollution problems? We very often see people blaming public and government sectors to control pollution through controlling market mechanisms and government blaming people to avoid and check pollution. Who would control whom? Many ecologists and environmental scientists believe in that pollution problems can be overcome by using market mechanisms to reduce pollution rather than rigid rules and regulations. However, on the other hand man should identify and gear up his own potential to curb down pollution. Man could achieve this by identifying his own role at individual level in prevention of pollution. This is possible through environmental awareness, education and enlightenment. Ways and means by which pollution problems can be greatly reduced at individual level are:

1. Masses at personal level should determine to consume optimum level of resources, which would lead a comfortable life. Because excessive resource consumption is in someway related to pollution problems and hazards (natural and anthropogenic both).
2. Waste disposal at personal level should be optimally reduced as waste destruction by any means causes pollution.
3. Maintenance of vehicles should remain proper as to avoid introduction of harmful gases and other pollutants in to the atmosphere.
4. Generators and other household gadgets that add to pollution of environment should be kept well maintained.
5. Use of chemical fertilizers should be limited as to avoid water pollution e.g. DDT
6. Timely disposal of waste to prevent decomposition of household refuge as to check foul odours and spread of disease by insects, flies and other pathogenic bacteria.

7. Industrialists should check for proper disposal of treated water from factory units as to avoid thermal pollution of water bodies. They should also deploy a water treatment plant to prevent the flow of hazardous material.

8. Service centres of vehicles should minimize the disposal of organic solvents into the main drains.

9. Music lovers should listen and operate their music systems at optimum levels asto avoid noise pollution.

**Radiation**

The radiations from the atomic blasts cause several health hazards. The radiations carry high energy and remove electrons from atoms and attach them to other atoms producing positive and negative ion pairs. Hence, they are known as ionizing radiations. The ionization property of these radiations proves to be highly injurious to the protoplasm. The ionizing
radiations of ecological concern are classified as follows:

**Corpuscular Radiations**

These consist of streams of atomic or subatomic particles, which transfer their energy to the matter they strike.

(i) Alpha particles

These particles are large and travel few centimeters in the air. These cause large amount of local ionization.

(ii) Beta particles

These are small particles characterized by having high velocities. They can travel a few meters in space. These are capable of entering into the tissues for few centimeters. Since alpha and beta particles have low penetration power they can produce harmful effects only when absorbed, ingested or deposited in or near living tissues.

(iii) Electromagnetic radiations

Electromagnetic radiations include waves of shorter wavelengths. These are capable of traveling long distances and can readily penetrate the living tissue. These include gamma rays. These can penetrate and produce effect even without being taken inside.

**Other Types of Radiations**

Besides radioactive radiations, some other radiations are also present in the atmosphere.

(i) Neutrons

These are large uncharged particles, which do not cause radiation by themselves, but they produce radioactivity in non-radioactive materials through which they pass.

(ii) X-rays

These are electromagnetic waves very similar to gamma rays, but originate from the outer electron shell of radioactive substances, which are not dispersed in nature.

(iii) Cosmic rays

These are radiations from the outer space, which contain alpha and beta particles together with gamma rays.

**Sources of Radiations**

The radiations are produced from the radioactive elements, which are known as radionuclides or radioactive isotopes, e.g. Uranium. Radium, Thorium, and Carbon-14. These contribute to background radiation. But isotopes of certain metabolically important elements like Carbon-14, Cobalt-60, Calcium 45, Iodine-131, Phosphorus-32, etc. are not ecologically harmful but are used as tracers. The third category of radionuclides comprises of fission products of uranium and certain other elements. These are cesium, strontium, and plutonium etc.

**Biological Effects of Radiation**

The effects of radiation have revealed that acute doses are found to be deleterious and may kill the organisms, whereas the increase in radiation in biological environment leads to different kinds of mutations. The effects of Cobalt-60 or Cesium-137 gamma radiations have now been studied on communities and on ecosystems at different places. The research

concludes that Irradiations eliminate varieties in species. The sensitivity of cells, tissues and organisms to radiation varies. The cells with larger chromosomes are more sensitive. Herbaceous communities and early stages of succession are resistant than the mature forest.

**Nuclear Fall Outs or Radioactive Fall Outs**

The atomic blasts not only produce the local ionizing radiations at that time but the radioisotopes produced as a result of explosion enter the atmosphere and continue to fallout gradually over broad geographic areas for a very long time. These are known as nuclear fallout or radioactive fallout. These are dangerous for life as they also produce ionizing radiations.

**Biological Effects of Fall outs**

The fallout of radionuclides combines with various metals and dust and from colloidal suspension combines with organic compounds to form complexes. The smaller particles of radionuclides adhere tightly to the leaves of plants and produce radiation damage to leaf tissue besides entering the tissues also. Through grazing animals these enter the food chain

directly at the primary consumers level. Radionuclides, which combine with organic substances, enter the food chain through producer tropic level. Therefore, the radionuclides fall out manages to enter the body of all living organisms. Radioactive Strontium-90 poses a health hazard in human beings and other higher vertebrates. It continues to deposit in

the bones and causes bone cancer and leukemia. Radioactive Cesium-137 is known to cause irreversible genetic changes in different organisms. The fallout radiations do cause changes in the genetic constitution of organisms, resulting in gene mutations and chromosomal aberrations. Their considerable, doses may kill, cripple and alter the animals and plants in the areas.

**Control of Radiation Pollution**

Following measures can help in controlling the radioactive pollution:

(*i*) Workers in nuclear plants should be provided with nuclear gadgets and safety measures against accidents.

(*ii*) Leakage of radioactive elements from nuclear reactors, laboratories, transport careless handling and use of radioactive fuels should be checked.

(*iii*) Level of radiation pollution should be monitored regularly in risk areas.

(*iv*) Disposal of radioactive wastes deserves special attention.

**Lecture No: 08**

## Solid waste management: Causes, effects and control measures of urban and industrial waste

In ancient cities, food scraps and other wastes were simply thrown into the unpaved streets where they accumulated. Around 320 B.C. in Athens, the first known law forbidding this practice was established and a system of waste removal began to evolve in several eastern Mediterranean cities. Disposal methods were very crude and often were just open pits outside the city walls. As populations increased, efforts were made to transport the wastes out further thus creating city dumps. Until recently the disposal of municipal solid waste did not attract much public attention. The favoured means of disposal was to dump solid wastes outside the city or village limits. Around most towns and cities in India the approach roads are littered with multi-coloured plastic bags and other garbage. Waste is also burnt to reduce its volume. Modern methods of disposal such as incineration and the development of sanitary landfills, etc. are now attempting to solve these problems. Lack of space for dumping solid waste has become a serious problem in several cities and towns all over the world. Dumping and burning wastes is not an acceptable practice today from either an environmental or a health perspective. Today disposal of solid waste should be part of an integrated waste management plan.

The method of collection, processing, resource recovery and the final disposal should mesh with one another to achieve a common objective. Characteristics of municipal solid waste Solid wastes are grouped or classified in several different ways. These different classifications are necessary to address the complex challenges of solid waste management in an effective manner. The term municipal solid waste (MSW) is generally used to describe most of the non-hazardous solid waste from a city, town or village that requires routine collection and transport to a processing or disposal site. Sources of MSW include private homes, commercial establishments and institutions as well as industrial facilities. However MSW does not include wastes from industrial processes, construction and demolition debris, sewage sludge, mining wastes or agricultural wastes.

Municipal solid waste contains a wide variety of materials. It can contain food waste such as vegetable and meat material, left over food, egg shells, etc which is classified as wet garbage as well as paper, plastic, tetrapacks, plastic cans, newspaper, glass bottles, cardboard boxes, aluminum foil, metal items, wood pieces, etc. which is classified as dry garbage.

Control measures of urban and industrial wastes: An integrated waste management strategy includes three main components:

1. Source reduction 2. Recycling 3. Disposal

**Lecture No: 09**

## Social issues and climate change

Climate has from the very beginning regulated man in practically every aspect of life and has played a very important role in the development of civilizations all around the world. Man's impact on climate began 5000 to 9000 years ago, as he was able to alter the environment by burning and felling forest and tilling the earth. The most extensive change wrought by man prior to our own times was the gradual conversion of most of the temperate forest zone to crops that is an artificial steppe or savanna. Thus until the industrial revolution and probably until the present century, man had little effect on the climate except on a very local scale.

Presently global warming has emerged as one of the most important environmental issues ever to confront humanity. This concern arises from the fact that our everyday activities may be leading to changes in the earth's atmosphere that have the potential: to significantly alter the planet's heat and radiation balance, and thereby lead to a warmer climate in the next century and thereafter. International efforts to address this problem have been on for the last decade, with the Earth Summit at Rio in 1992 as an important launching point and the Conference of Parties in Buenos Aires. In 1998 as the most recent step. Although India as a developing country does not have any commitments or responsibilities at present for reducing the emissions of greenhouse gases such as carbon dioxide (CO2) that lead to global warming, pressure is increasing on India and other large,

rapidly developing countries such as China and Brazil to adopt a more pro-active role.

**Extreme Weather Events**

In addition, most of the ill effects of climate change are linked to extreme weather events, such as hot or cold spells of temperature, or wet or dry spells of rainfall, or cyclones and floods. Predictions of the nature and distributions of such events in a changed climate are even more uncertain- to the extent that virtually no authoritative predictions exist at all. While there are costs as well as benefits associated with climate change, the scientific consensus is clearly that the overall effects are likely to pose a significant burden on the global community. Unlike many other environmental issues, such as local air or water pollution, or even stratospheric ozone depletion caused by chlorofluorocarbons (CFCs), global warming poses special challenges due to the spatial and temporal extent of the problem covering the globe and with decades to centuries time scales. Analysis and assessment of just what steps needed to be taken to limit greenhouse gas emissions. This process resulted in the negotiation' of a protocol, the final details of which were completed at the third meeting of the Conference of the Parties to the Framework Convention held December 1-12, 1997, in Kyoto, Japan. The Kyoto Protocol to the United Nations Framework Convention on Climate Change commits industrialized nations to specific, legally binding emission reduction targets for six greenhouse gases: carbon dioxide, methane, nitrous oxide, hydro fluorocarbons, per-fluorinated compounds and sulphur hex fluoride.

First, although India does not currently have any obligations under the Convention to reduce its greenhouse gas emissions. It is important for us to develop a clear understanding of our emission inventory. We also need to document and analyze our efforts in areas such as renewable energy, wasteland development and a forestation - all of which contribute towards either reducing CO2 emissions or increasing CO2 removal from the atmosphere. Considering that these efforts may often be undertaken for a variety of reasons not directly related to global warming, but yet has

benefits as far as climate change is concerned, we may be able to leverage such efforts in the international context. The Research community could contribute substantially in this regard. We need to significantly improve our ability to plan and adapt to extreme events such as floods, droughts, cyclones and other meteorological hazards. Any robustness that we build into the system in this regard will always stand us in good stead no matter what climate change actually transpires.

**Global Warming and the Greenhouse Effect**

In the late 1900's researchers realized that the world may be getting warmer. The last two decades of the 1900's witnessed some warm and cool years. However, not enough evidences were available to support the theory of global warming. But this a well-known fact that accumulation of several green house gases can lead to a rise in temperature (global warming). If a global warming phenomenon sets in this would result in major changes in world's climate. The increase in temperature might lead melting of snow on poles, which would terrifically add, to ocean waters. Hence the level of seas, and oceans would rise, this would largely affect the coastal areas. These would submerge under coastal Waters due to expansion of seas and oceans. Besides the Temperate climate pattern would shift northward nd present temperate regions would become hot & dry.

The Greenhouse Effect is a natural phenomenon that plays a central role, in determining the earth's climate. The hot surface of the sun radiates heat and light energy. Several gases in the atmosphere are transparent to light but absorb infrared radiation. These allow sunlight to pass through the atmosphere and be absorbed by the earth's surface. This energy, is again radiated as heat energy, which is absorbed by the gases. As the effect is similar in nature to what happens in a' botanical greenhouse (the glass panes allows the light energy to enter inside but diminishes the loss of heat), these gases are called greenhouse gases and the resultant warming from their increase is called the greenhouse effect. Anthropogenic activities add to the phenomenon accelerating greenhouse gas building process. Global increase of greenhouse gases in the atmosphere viz., carbon dioxide, nitrous oxide, methane and chlorofluorocarbons are now well documented. In addition to all these changes, troposphere and stratospheric chemistry are being modified due to the addition of these gases as well

as emission of carbon monoxide, nitrogen oxides and other compound. The United State Environmental Protection Agency, Office of Policy, Planning and Evaluation in 1989 have documented the increase of the different green house gases.

**Major Green House Gases Contributing to Global Warming**

1. Carbon dioxide 57
2. Chlorofluorocarbons 25
3. Methane 12
4. Nitrous oxide 6

The concentration of carbon dioxide into the atmosphere has increased by 25% since the industrial revolution. Carbon dioxide is increasing at a rate of about 0.4% per year and is responsible for about half of the current increases in the greenhouse effect. The concentration of methane has more than doubled during the last three centuries. Agricultural sources particularly rice cultivation and animal husbandry has probably been the most significant contributors to historical increase in concentrations. But there is the potential for rapid growth in emissions from

landfills, coal seems, permafrost, natural gas explorations and pipeline leakage, and biomass burning associated with forest clearings in the future.

The concentrations of nitrous oxide have increased by 5-10% since pre-industrial times. The cause of this increase is highly uncertain, but it has been understood that the use of nitrogenous fertilizer, land clearing biomass burning and fossil fuel combustion have all contributed. Nitrous oxide is currently increasing at a rate of about 0.25% per year, which represents and imbalance between sources and sinks of about 30%. CFC's were introduced into the atmosphere for the first time during the century; the most common species are CFC-12 and CFC-II. Of major concern because of their potential to deplete stratospheric ozone, the CFCs also represent about 15% of the current increases in the greenhouse effect. The chemistry of the atmosphere is changing due to emission of carbon monoxide, nitrogen oxides, and volatile organic compounds, among other species, in addition to the changes in the greenhouse gases already described. This alters the amount and distribution of ozone and the oxidizing power of the atmosphere. which changes the lifetimes of methane and other greenhouse gases. Changes in global ozone are quite uncertain, and may have contributed to an increase or decrease in the warming commitment during the last decade.

**Acid Rain**

Although the phenomenon of "acid rain" (more correctly acid deposition) was identified in Manchester, England, as long ago as 1852, and described more thoroughly in 1872, modern scientific research has been going on only since the mid-1950s. Public concern about the problem began in the late 1960s. Acid rain is an environmental hazard that is transponder in nature. Northeastern America, North Western Europe and India are facing an acute problem of acid rain. Acid rain has affected certain rivers, lakes, streams and forests in United Kingdom (UK), United States of America (USA), Germany and many other countries. Acid rain literally means 'the presence of excessive acids in rain waters'. Acid precipitation is a mixture of strong mineral acids sulphuric acid (H2SO4), nitric acid (HNO3) and in some locations, hydrochloric acid (HCl). It usually has a ph of less than 5.6, the value of distilled water in equilibrium with atmospheric carbon dioxide.

**Acid in the Rain Water's**

Acid rain problem is a result of anthropogenic activities. Most acids come from cars, homes, industries and power stations but some share is contributed by natural sources such as volcanoes, swamps and planktons. The acid problem is basically associated with the transport and subsequent deposition of oxides of sulphur, nitrogen and their oxidative products. These are produced by combustion of fossil fuels, power plants, automobile exhausts and domestic fires etc.

**Formation of Acid Rain**

Acid rain is one of the form of acid deposition which can either be wet or dry, acid rain, snow, dew, fog, frost and mist are the wet form of deposition, while dust particles containing sulphate and nitrates which settle on ground is called dry deposition.

<u>Wet Acid Rain</u>

Coal, fuel wood or petroleum products have sulphur and nitrogen. These elements, when burnt in atmospheric oxygen,' are converted into their respective oxides (SO2 and NO3), which are highly soluble in water. By anthropogenic and by natural sources, oxides of sulphur and nitrogen enter the atmosphere.

**Reactions**

Reaction with Sulphur

$S + O2 = SO2$

$2SO2 + O2 = 2SO3$

Reaction with Nitrogen

$NO + O3 = NO2 + O2$

$NO3 + NO2 = N2O5$

When air is saturated with water droplets (humid conditions), $N2O5$ invariably reacts with water vapors to form droplets of $HNO3$.

$N2O5 + H2O = 2HNO3$

Besides some $HNO2$ is also formed

$N2O3 + H2O = 2HNO2$

$SO3$ in humid conditions forms droplets of $H2SO4$.

$SO2 + 1/202O2 + H2O = H2SO4$

$HNO3$ and $H2SO4$ thus formed combine with HCl to generate precipitation, which is commonly referred to as acid rain.

The primary reason for concern is that acid deposition acidifies streams, and taken on coarse, sandy soils low in lime: The effect is seen particularly in headwater areas and in wet montane environments, wherever sulphate loading from anthropogenic sources is strong. The chemical and physical consequences of lake acidification include, increased leaching of calcium from terrestrial soils, mobilization of heavy metals such as aluminium, zinc, and manganese and an increase in the transparency of lake waters. The biological consequences include market changes in communities of aquatic plants and animals, with a progressive lessening of their diversity.

Acid deposition may further impoverish forests soils, developed on sandy substrata poor in lime. As a consequence of accelerated leaching of nutrients, such as phosphorous, potassium, magnesium and calcium from these soils, forest productivity would eventually be reduced. Moreover, the acid sulphate particles that contribute to acid precipitation are in the size range that penetrates deep into the lung, and they may well exacerbate lung diseases and increase mortality rates.

**Ozone Layer Depletion**

Joseph Farman, of the British Meteorological Survey, and colleagues reported in the scientific journal Nature that concentrations of stratospheric ozone above Antarctica had plunged more than 40 percent from 1960s baseline levels during October, the first month of spring in the Southern Hemisphere, between 1977 and 1984. It meant that for several months of the year a hole forms in the ozone layer, which protects animals and plants from ultraviolet solar radiation. Suddenly it seemed that the chemical processes known to deplete ozone high in the earth's atmosphere were working faster and more efficiently than predicted.

**Lecture No: 10**

# Environmental ethics

**Sustainable and development**

The term sustainable was development and introduced by the World Commission on Environment and Development (The Brundtland Commission), in its seminal report of 1987, Our Common Future. The concept has terrifically worked out in creating public awareness for sustaining the planet with better management. The sustainable development has been defined as "meeting the need of the present generation without compromising the needs of future generation". The concept precisely emphasizes upon using the earth resources judiciously and compensating for it in some sense e.g. if cut few trees to support our lives, we should also implant some new ones at some site. This would result in. maintaining the earths fine balance between resource consumption and resource generation.

In understanding this concept we very often encounter two terms- sustainable and development. These are summarized below as:

**Sustainable**

The literal meaning of sustainability is "that can be maintained" or "keep goal continuously". In ecological sense it refers to "conservation of ecological balance by avoiding depletion of natural resources". Hence, we can understand it as something, which has got to do with longevity (long life) of a resource, commodity, species, ecosystem, earth etc.

**Development**

The literal meaning of development is "the act or instance of growth/advancement". So the growth can be of many types viz., growth of education, growth of industry, growth of population, growth of forests and many other. But what type of growth are we addressing to? Here we are addressing to one of the most sensitive issue of growing concern 'about improving the well-being of human beings. This could be achieved only through compromising with some of our comforts and luxuries. The generation of comforts and luxuries brings environment under great pressure. The Nations economic growth should not stand upon the fragile foundation of earth's resources. Mahatma Gandhi a great social scientist, rightly 192 "The earth provides enough to satisfy everyone's need, but not everyone's greed".

In the context of economical and technical development the world always had been better today than yesteryears and will always be better tomorrow than today. But the condition of environment will always be poorer than before. Hence, the concept of sustainable development raises certain questions for the present generations to answer. What is our present? Are we happy with our present? Prospective changes of the magnitude described above raises fundamental questions about the kind of world we will bequeath to our children and about the nature and goals of development. The present in which we live is important as it shapes our future. Nothing much can be done to recover the damages imposed on nature in the past. But if we shape our surroundings based on environmental ethics and economically exploit our present environment we would lend a healthier tomorrow to our children. As we have examined some environmental issues in the previous chapters, we would commonly agree that human population growth, loss of biodiversity, habitat destruction, ozone depletion, global climate change, pollution (air, water, noise etc.) and limited food & energy supply are environmental concerns of global scale. In the past two decades a great deal of work from researchers, ecologists, environmental scientists, social scientists, geographers and demographers have build up a very clear picture of what our tomorrow would be like: Some initiatives have been taken up both at government and non-

government level. Still promising environmental concern at individual level is far lacking beyond sustainable needs.

Although population growth continues to expand at an unsustainable pace but still certain countries have achieved a demographic transition to zero population growth. However, positive signs from developing nations are still absent. We have achieved breakthroughs in renewable energy sources, agro-forestry schemes and better pollution control advancements. Increased man awareness, resourcefulness and enterprise will help eliminate poverty and resource wastage and will make our environment a much better place to live in. Until environmental concerns do not find space in our heart we would never be able to delicately handle our surroundings when we are at home or public. We should recognize things at personal and collective grounds to protect nature and to create a sustainable environment.

**Urban Problems Related to Energy**

Big cities and towns have always influenced education, religion, commerce, communication and politics, which have in turn influenced culture and society in various proportions. Initially only a very limited section of the society lived in cities and towns while the chief occupation of major population had been fishing, hunting, agriculture and cattle rearing. However' Industrial Revolution lead to expansion of cities and town both in size and power. In developing nations, especially a large segment of society from villages moved to cities for occupational support (occupational migration). This exactly was the cause of rapid expansion of cities' and formation of metropolitans like Delhi, Bombay, Chennai, Bangalore, Calcutta and others. This ultimately brought into picture the concept of urbanization and industrializations, which provided many benefits to society, especially to the rich, but also introduced some evils in it. Here evils referred to were the increasing demand on energy resources; whose consumption in turn lead to multitude problems of pollution, resource
shortage, diseases and waste disposal. Some of the major urban problems related to energy are as under:

(i) Electricity

Electricity from various sources is a major requirement of expanding cities, towns and villages. Each and every activity of mans life is now someway related to electricity consumption. Housing gadgets like mixer-grinder, T.V., computer, music systems, geysers, fans, lights, A.C.s, microwave, water lifting pump, warm blowers, coolers, etc. form the essential components of a house. This all together has led to an electricity energy crunch. It is well known that some part of electricity is lost in transmission and greater part is stolen. The remainder is simply not enough to support the majority of people in the city and that's why the problem of electricity in cities is on the rise. The buildings are empowering the cities like anything but nowhere we see dams, supplying electrical units, increasing in number at the same pace. Therefore, what majority of the cities face today is a usual cut of electricity for a minimum of 6-8 hrs. This makes today's urban life handicapped. Resourceful enjoy the resource benefit from the rising generator and inverter culture, which in turn put pressure on resources and lead to pollution problems.

(ii) Fossil fuels (petroleum, natural gas and coal)

Fossil fuels have always been under a great threat from times immemorial. In the absence of technological advancements these have served mankind for several years. In this quest for energy the coal reserves have suffered a lot. With rise in technical know how man started

generating power from nuclear sources, hydroelectric power, wind power etc. But still these contribute a little. We still depend on thermal power a lot.

(*a) Petrol and Diesel:* Transport and communication has brought the petroleum reserves of the world under a great threat. The rise in number of vehicle per year is immense. To understand the gravity of the problem a glance of metropolitan roads and lanes is enough. Even the roads and lanes of big cities, small cities and towns are loaded with two wheelers.

(*b) Natural Gas:* The common usage of natural gas is in the form of Liquid Petroleum Gas (LPG). There is a terrific rise in the usage of LPG driven household commodities with the expanding population. Earlier the LPG usage was only limited to kitchen for cooking. The advent of technology introduced a numerous household items making its use like gas geysers, gas heaters, gas fans, gas lanterns etc. In a way it is serving as a substitute of electricity, which is other reason for increasing

pressure on oil wells/reserves.

(*c) Coal:* The world population has extracted and used coal reserves thinking as if it is a never-ending commodity/resource. It has served Sustainable Development, Urban Problems,

— Water Conservation and Management,

— Resettlement and Rehabilitation of People,

— Environmental Ethics,

— Global Warning,

— Environment Protection Act,

— Issues involved in Enforcement of Environment Legislation, Millions throughout the ages. Earlier it was primarily used to support kitchens. People also utilized it for heating stoves/ heaters in colder regions of the world. Later, its usage in the railways became the chief cause of its rapid exhaustion. Coal reserves are a limited source of energy now. It should be used judiciously and economically.

(iii) Fuel wood

Fuel wood being used for the ignition of fire is chiefly responsible for the destruction of impoverished forestlands. Though fuel wood collection to support family daily chores is allowed in certain parts of the forest generally the outskirts but the greed and dearth compels women to penetrate deep into the forest. Generally the big cities are characterised by the absence of forestland at the fringes. But whatever degraded forest is available serve as a source of fuel wood even in and around urban centres e.g. Dehradun is a well developed city, but in its fringes we can still see women and children carrying loads of fuel wood.

**Water Conservation**

We could save as much as half of the water we now use for domestic purposes without great sacrifice or serious changes in our lifestyles. Simple steps, such as taking shorter showers, stopping leaks, and washing cars, dishes, and clothes as efficiently as possible, can go a long way toward forestalling the water shortages that many authorities predict. Isn't it better to adapt to more conservative uses now when we have a choice than to be forced to do it by scarcity in the future?

**Rain Water Harvesting**

Water is commonly taken for granted as nature's gift. Often it is used wastefully in agriculture, but industry and people pollute and poison available water supplies at an alarming rate. Water problems arise from increasing demands generated by rapid population growth; urbanization, industrialization and irrigation for additional food production. In many areas excessive pumping

of groundwater not only brings down water quality, but also depletes it this affects' sustainability. The 'capacity of irrigation tanks numbering about five lakh in the country is shrinking due to situation and encroachment. Scarcity is noticed even in high rainfall areas like Cherrapunji (Assam), Western Ghats and Kerala. This is due to improper management and poor conservation of rainwater.

India's water potential is substantial but the scarcity is felt everywhere even for drinking. This is because the country's water policy and management is not very specific and implementation is poor. Total rain in the country is about 400 M hm (million hectare meters). The runoff in the rivers is estimated at 186 M ha. Further the utilizable groundwater is calculated as 40 M hm. However, the utilizable quantity is about 110-115 M hm (70 M hm from surface and 40 M hm from groundwater). To meet the relentless increase in demand for water for various purposes and to achieve the goal of optimal use and to get the maximum benefits, it is necessary to make water resource development holistic through a comprehensive integrated river basin planning and management. This can be done only if a wide range of disciplines are involved. Wastage of water due to leakage in pipes and unattended repairs results in about 30-40 per cent water resource lost.

The landscape watershed units can be effectively subdivided into discrete hydrological units. Since the watersheds are spatially laid from ridge to valley, they most efficiently conserve land and water resources and help secure water availability throughout the growing season. The land area of the watershed drains into a common point. Hence, the drainage water can be easily stored in above -ground storage structures for recycling during droughts or for growing an additional crop. Rain fed agriculture research and development has been dominated by the concept of high yields for decades. It arose from the scientific principles developed for the 'green revolution' high input, high-output technologies. Fatigue and cracks are now developing in the green revolution areas. For rain fed agriculture, an area-based development through watershed management provides an excellent framework for sustaining semi-arid tropical ecologies. Also the landscape watershed units focus on the maintenance of managed biodiversity through diversified cropping systems. It is significant to note that a broad range of baseline information on watershed-based soil and water conservation Technologies already exists. A study commissioned by the National Institute of Agricultural Extension Management, Hyderabad, showed that if the watershed technology is to succeed it must be specific to natural endowments of the location; it must be built on indigenous knowledge; it should be based on people's participation; it must be equitable in sharing of costs and benefits, and village-based institutions must be put-in-place right from inception of the project.

**Watershed Management**

It was suggested that, rather than allowing residential, commercial, or industrial development on flood plains, these areas should be reserved for water storage, aquifer recharge, wildlife habitat, and agriculture. Sound farming and forestry practices can reduce runoff. Retaining crop residue on fields reduces flooding, and minimizing. Ploughing and forest cutting on steep slopes protects watersheds. Wetlands conservation preserves natural water storage capacity and aquifer recharge zones. A river fed by marshes and wet meadows tend to run consistently clear and steady rather than in violent floods.

A series of small dams on tributary streams can hold backwater before it becomes a great flood. Ponds formed by these dams provide useful wildlife habitat and stock-watering facilities. They also catch soil where it could be returned to the fields. Small dams can be built with simple

equipment and local labour; eliminating the need for massive construction projects and huge dams. Watershed-based frame for rain fed agriculture provides uncommon opportunities for achieving sustainable food and nutritional security. It is time that the watershed development agenda is considered a programme for-the masses.

**Resettlement and Rehabilitation of People**

"Land for land" is a better policy than cash settlement. Even in implementing this policy, the land is not given in the command area in most cases, forestland is either cleared on waste fallow land given without any provision for developing the land or for the supply of necessary inputs; a village is broken up and families dispersed; villagers are usually left to buy private land, take loans from the government, which puts poor villagers at a disadvantage- land prices in neighboring villages shoot up steeply if the government takes up resettlement; the villagers are resettled in distant places, sometimes in a totally alien environment and culture, thus creating insurmountable adjustment problems. Oustees from Pong dam in Himachal Pradesh were settled in Anupgarh in Rajasthan, bordering on Pakistan.

The people were generally left to fend for themselves. Arrangements for drinking water, dispensaries, schools, village roads or drainage of the rehabilitation sites are only completed years later. In the case of the Ukai Dam in Gujarat, resettlement work was undertaken by the 'Ukai Nav Nirman Samity. Even so, out of a total of 18,500 affected families, only 3500 families could be resettled.

People who could previously barely manage to survive in their traditional environment are uprooted as a result. The objectives of rehabilitation should be: 1. The people displaced should get an appropriate share in the fruits of development.

2. Creating new settlements with their own environment should rehabilitate them.

3. Removal of poverty should also be an objective of the rehabilitation policy and therefore some land to all.

4. Oustees (even the landless) should be given assurance of employment.

5. While dealing with tribal one should also keep in mind the following five principles of tribal-development accepted during Jawaharlal Nehru's era as 'tribal panchsheel.'

6. Tribal should develop along the lines of their own genius and we should avoid imposing anything on them.

7. We should try to encourage their own traditional arts and culture in every way.

8. Resettlement should be in the neighborhood of their own environment. If resettlement is not possible in the command area, top priority should be given to the development of irrigation facilities and supply of basic inputs for agriculture; drinking water, wells, grazing grounds for cattle schools for the children, primary health care units and other amenities should be arranged.

9. In partly affected village, villagers should be given the option of shifting out with others with the same compensation as available to evacuees.

10. Training facilities should be set up to upgrade the skills of affected people and reservation in jobs should be made for the willing adults among the evacuees.

11. Special attention should be given to the rehabilitation of artisans and village crafts people.

12. Villagers should be taken into confidence at every stage or implementation and they should be educated, through open meetings and discussion about the legalities of the Land Acquisition Act and other rehabilitation provisions.

13. The aid of voluntary agencies planning and implementation programme.

**The Aids Pandemic**

The AIDS (Acquired Immune Deficiency Syndrome) virus has caused a worldwide epidemic, which can be called a pandemic because it continues to spread throughout the world. Millions of people have been infected. The virus was first identified as the cause of AIDS in the late 1970s. Since then, individuals with the infection have been reported in nearly every country in the world. Estimated mortality rates are about 60 percent, according to the U.S. Centres for Disease Control and Prevention. The disease is spread through direct physical contact, between individuals in which body fluids containing the, virus enter the bloodstream. Sharing of contaminated needles among intravenous drug users and sexual contact are the most-likely methods of passage. In the United States, the disease was once considered a problem only for the homosexual community and those who use intravenous drugs. This perception is rapidly changing. Many of the new cases of AIDS are being found in women infected by male sex partners and in the children of infected women. In parts of Africa, the disease has always been primarily a heterosexual disease. In the poor countries of central Africa, many believe that permissive sexual behaviour and prostitution have created conditions for a rapid spread of the disease. In addition, there is little opportunity for medical care. Many people have already died from the disease. Others who are currently infected will die in the near future. Some villages are already beginning to notice a change in the structure of their populations. With the death, of young infected' adults, villages are composed primarily of older people and children. The disease is spreading at an alarming rate, and, it has no cure as yet and no vaccine so far. The disease is almost fatal. People in the age group 20-39 are more susceptible to getting AIDS.

***Causative germ of AIDS*** is a virus named HIV (Human Immunodeficiency Virus). It has been detected in body fluids like blood, semen, saliva, tears and urine. It attacks the immune system (i.e. the' cells that fight against infections) and the patient suffers seriously from even minor infections of other diseases. Even cancers appear when the immune system fails.

**Incubation period** i.e. the time between receiving the infection and the' appearance of symptoms may even be more than 10-12 years. During this period the persons show positive results for HIV infection and they are popularly called HIV-positive. Most individuals, when AIDS is fully developed, die within 3 years from other infections or cancers. Symptoms during this period may include swollen lymph nodes, fever, night sweats and weight loss.

**Transmission of Aids**

The AIDS virus is highly infective. It is transmitted by any one of the following methods:-

(*i*) **Sexual intercourse** between a man and woman, when anyone of two is infected. (The virus occurs in the fluids of the reproductive passages). Prostitution is the biggest source to spread the infection. Safest is the single partnership wife and husband relationship.

(*ii*) **Homosexual intercourse** (anal sex) with an infected person. The disease is more common in homosexual males.

(*iii*) **Contaminated blood transfusions.** In many situations the patients have to be given blood transfusions as in excessive bleeding resulting from injury, or during surgery, etc. Some children are born with the disease thalassemia with defective hemoglobin of the blood. Such children have to be given regular blood transfusions usually every 3-4 weeks and very often the blood transfused is from professional donors.

(*iv*) **Mother to child transmission.** The germ from the infected mother may cross through the placenta and reach the embryo in the womb.

(*v*) **Injection needles** if shared by more than one person may introduce the virus from one individual to another. The disease is quite. common in drug abusers. For the same reason, doctors in hospitals now use only disposable syringes, which are used just once. AIDS is not transmitted by contact with patient's clothes and other articles, shaking hands, eating together and sharing bathrooms and toilets.

**Lecture No: 11**

# The Environment Protection Act, 1986

(No. 29 of 1986) An Act to provide for the protection and improvement of environment and for matters connected therewith. Whereas decisions were taken at the United Nations Conference on the Human Environment held at Stokholm in June 1972, in which India participated, to take appropriate steps for the protection and improvement of human environment; Short Title, Extent and Commencement

1. This Act may be called the Environment (Protection) Act, 1986.
2. It extends to the whole of India.
3. It shall come into force on such date as the Central Government may, by notification in the Official Gazette, appoint and different dates may be appointed for different provisions of this Act and for different areas.

The Act clearly states and explain each and every term very precisely like environment, environmental pollutants, environmental pollution, handling, hazardous substance, occupier, prescribed. General Powers of the Central Government Power of Central Government to take measures to protect and improve environment.

1. Subject to the provisions of this Act, the Central Government shall have the power to take all such measures, as it deems necessary or expedient for the purpose of protecting and improving the quality of the environment.
2. Planning and execution of a nationwide programme for the prevention, control and abatement of environmental pollution;
3. Laying down standards for the quality of environment in its various aspects;
4. Laying down standards for emission or discharge of environmental pollutants from various sources.
5. Restriction of areas in which any industries, operations or processes or class of industries, operations or processes shall not be carried out or shall be carried out subject to certain safeguards;
6. Laying down procedures and safeguards for the handling of hazardous substances;
7. Examination of such manufacturing processes, materials and substances as are likely to cause environmental pollution;
8. Carrying out and sponsoring investigations and research relating to problems of environmental pollution;
9. Inspection of any premises, plant, equipment, machinery, manufacturing or other processes, materials or substances and giving, by order, of such directions touch authorities, officers or persons as if may consider necessary to take steps for the prevention, control and abatement of environmental pollution;
10. Preparation of manuals, codes or guides relating to the prevention, control and abatement of environmental pollution.

**Air Pollution Act, 1981**

An Act to provide for the prevention, control and abatement of air pollution, for the establishment, with a view to carrying out the aforesaid purposes, of Boards, for conferring on and assigning to such Boards powers and functions relating thereto and for matters' connected therewith. Whereas decisions were taken at the United Nations Conference on the Human Environment hold in Stockholm in June, 1972, in which India participated, to take appropriate

steps for the preservation of the natural resources of the earth which, among other things, include the preservation of the quality of air and control of air pollution and whereas it is considered necessary to implement the decisions aforesaid in so far as they relate to the preservation of the quality of air and control of air pollution.

Short title, extent and commencement

1. This Act may be called the Air (Prevention and Control of Pollution) Act, 1981.
2. It extends to the whole of India.
3. It shall come into force on such date as the Central Government may, by notification in the official Gazette, appoint.

The Act clearly states and explain each and every term very precisely air pollutant, air pollution, approved appliances, approved fuel, automobile, central board, chimney, control equipment, emission, industrial plant, member, occupier, prescribed, state board.

**Water Pollution Act, 1974**

An Act to provide for the prevention and control of water pollution and the maintaining or restoring of wholesomeness of water, for the establishment, with a view to carrying out the purposes aforesaid, of Boards for the prevention and control of water pollution, for conferring on and assigning to such Board powers and functions relating thereto and for matters connected therewith. Whereas it is expedient to provide for the prevention and control of water pollution and the maintaining or restoring of wholesomeness of water, for the establishment, with a view to carrying out the purposes aforesaid, of Boards for the prevention and control of water pollution and for conferring on and assigning to such Boards powers and functions relating thereto. Short title, application and commencement

1. This Act may be called the Water (Prevention and Control of Pollution) Act, 1974,
2. It applies in the first instance to the whole of the States of Assam, Bihar, Gujarat, Haryana, Himachal Pradesh, Jammu and. Kashmir, Karnataka, Kerala, Madhya Pradesh, Rajasthan, Tripura and West Bengal and the Union Territories; and it shall apply to such other State which adopts this Act by resolution passed in that behalf under clause (1) of the article 252 of the Constitution.
3. It shall come into force, at once in the States of Assam, Bihar, Gujarat, Haryana, Himachal Pradesh, Jammu and Kashmir, Kamataka, Kerala, Madhya Pradesh, Rajasthan, Tripura and West Bengal and in the Union Territories; and in any other State which adopted this Act under clause (1) of article 252 of the Constitution on the date of such adoption and any reference in this Act to the commencement of this Act shall, in relation to any State or Union Territory, mean the date on which

this Act comes into force in such State of Union territory. The Act clearly states and explain each and every term very precisely like board, central board, member, outlet, pollution, prescribed, sewage effluent, sewer, state board, state government, trade effluent etc.

**The Wildlife (Protection) Act, 1972**

An Act to provide for the protection of wild animals and birds and for matters connected therewith or ancillary or incidental thereto.

Short title, extent and commencement

1 This Act may be called the Wild Life (Protection) Act, 1972

2 It extends, in the first instance, to the whole of the States of Andhra Pradesh, Bihar, Gujarat, Haryana, Himachal Pradesh, Madhya Pradesh, Manipur, Punjab, Rajasthan, Uttar Pradesh and West Bengal and to all the Union territories; and it shall also extend to such other State as may

adopt this Act by resolution passed in that behalf in pursuance of CI. (1) of Art. 252 of the Constitution.

It shall come into force in a State of Union territory to which it extends, or may become extended in future, on such date as the Central Government may, by notification, appoint, and different dates may be appointed for different provisions of this Act or for different States or Union territories. The Act clearly states and explains each and every term very precisely like animal, animal article, big game, board, captive animal, cattle, chief wild life warden, closed area, collector, commencement of this act, dealer, director, game reserve, government property, habitat, hunting, land, license, manufacturer, meat, national park, notification, permit person, prescribed, sanctuary, small game, special game, state government, taxidermy, trophy, uncured trophy, vehicle, vermin, weapon, wild animal, wild life, wile life warden.

**Forest Conservation Act**

India's Forest Policies

Development of forest is guided by the policies adopted by a nation to manage them. Scientific forestry was adopted in India since over a century back. Country's first forest policy was enunciated in 1894. After the Independence Indian Republic therefore formulated her National Forest Policy in 1952. The National Commission on Agriculture established in 1970 went into the forestry situation in the country and suggested a need for a new forest policy, in their Report of 1976. The Constitution of the Independent India placed forests under the State List of the Seventh Schedule in 1950. The States were vested with the administration of the forests. The Constitution has recognized the importance of protection of forests and their improvement. It is stipulated in Article 48-A, that the State shall endeavourer to protect and improve the environment and to safeguard the forests and
wildlife of the country.

The period between 1950 and today has witnessed large-scale depletion of forests and attrition of forestlands. Forests lands were cleared and diverted to other uses like agriculture, industries, hydroelectric projects, settlement of displaced persons and foreign refugees, etc. This also resulted in diminishing wildlife in the country due to loss of their habitat. Realizing the importance of forests for the well being of the nation, the Parliament, by the 42$^{nd}$ Amendment to the Constitution, in 1976, brought Forests and Wildlife on the concurrent list in Seventh Schedule. In the year 1980, the President of India promulgated the Forest (Conservation) Ordinance, 1980, which put severe restrictions on de-reservation of forest or use of forestland for non-forest purposes, without prior approval of the Central Government.

Forests play three important roles in national economy of any country, they are: (*a*) protective, (*b*) productive, and (*c*) as a source of accessory benefits. This calls for an effective legislation. The Indian Forest Act, 1927, is in force today for the same purpose. Similarly a comprehensive legislation for the protection of wildlife and nature is to be found in the Wildlife (Protection) Act, 1972.

**Forest Policy of 1894**

Enunciated in 1894 India's first Forest Policy laid down 'public benefit' as the sole objective of the administration of public forest. The Policy suggested the maintenance of forests in hilly areas for preservation of climatic and physical conditions and for protection of cultivated plains below from the divesting action of hill torrents. Forests with valuable timbers were to be managed on commercial lines. The forests of inferior quality were to be managed mainly in the interest of local population.

Guiding Principles for Forest Policy India's Forest Policy was revised once again in 1988. The main plan of the revised Forest Policy of 1988 is protection, conservation and development of forests. Its aims are

(*i*) maintenance of environmental stability through preservation and restoration of ecological balance, (*ii*) conservation of natural heritage, (*iii*) check on soil erosion and denudation in catchments area of rivers, lakes and reservoir, (*iv*) check on extension of sand dunes in desert areas of Rajasthan and along coastal tracts, (*v*) substantial increase in forest/tree cover through massive a forestation and social forestry programmes, (*vi*) steps to meet requirements of fuel for wood, fodder, minor forest produce and soil timber of rural and tribal populations, (*vii*) increase in productivity of forest to meet the national needs; (*viii*) encouragement of efficient utilization of forest produce and optimum substitution of wood, and (*ix*) steps to create massive people's participation with involvement of women to achieve the objectives and minimize pressure on existing forests.

**Forest Conservation**

The increasing destruction and degradation of forests and tree lands especially in the Himalayas and other hill areas, is leading to heavy erosion of topsoil, erratic rainfall and recurring floods. Another area of concern has been degradation of forests due to biotic pressure. Guidelines have been framed for preparation of working plans and felling in forests. Some of the salient features are (*i*) working plans should be up-to-date and stress conservation (*ii*) preliminary working plan should have a multidisciplinary approach, (*iii*) tribal rights and concessions should be high-lighted along with control mechanisms, (*iv*) grazing should be studied in detail and specific prescriptions should cover fodder propagation, (*v*) shifting cultivation and encroachments need to be controlled (*vi*) clearfelling with artificial regeneration should be avoided as far as possible and clear-felling blocks should not exceed ten hectare in hills and 25 hectare area in plains, and (*vii*) banning all felling above 1,000 meter altitude for a few years should be considered to allow these areas to recover. Critical areas in hills and catchments areas prone to landslips, erosion, etc. should be totally protected and quickly afforested.

**Issues involved in enforcement of Environmental, Legislation.**

Politics and the environment cannot be separated. The late 1980s and early 1990s witnessed a new international concern about the environment, both in the developed and developing nations of the world. Environmentalism is also seen as a growing factor in international relations. This concern is leading to international cooperation where only tension has existed before. While there exists no world political body that can enforce international environmental protection, the list of multilateral environmental organizations is growing.

There is no international legislature with authority to pass laws; nor are there international agencies with power to regulate resources on a global scale. An international court at the Hague in the Netherlands has no power to enforce its decisions. Nations can simply ignore the court if they wish. This environmental "coming of age" is reflected in the broadening of intellectual perspective. Governments used-to be preoccupied with domestic environmental affairs. Now, they are beginning to broaden their scope to confront problems that cross international borders, such as transboundary air and water pollution, and threats of a planetary nature, such as stratospheric ozone depletion and climatic warming. It is becoming increasingly evident that only decisive mutual action can secure the kind of world we seek.

Factors Affecting International Environmental Laws

• **Identification and gravity of the problem:** It is easier tofind a solution to a problem once it is widely acknowledged as critical.

• **Statistics:** Sufficient fieldwork should be done to collect the required data on the extent of the problem to find possible solutions.

• **Geo-Location:** To identify the sources and cause of problems and the areas under its effects.

• **Law and order:** Whether countries have laws protecting the environment and administrative proceedings to enforce those laws.

• **National and international pressures:** Who favors and who opposes action on the issue in each country.

• **Infrastructure (Institutions and policies):** Whether there is a mechanism in place for cooperative action among the interested countries.

• **International cooperation:** Whether the affected countries have a tradition of cooperation or conflict.

**Indian scenario**

Laws need to be strengthened and implemented properly to protect the environment. Although India has a number of rules and regulations to protect the environment they have still not reached the stage of full compliance. The growth of environmental laws is a reflection of the speed with which environmentalism has established itself as a potent political force. But many of the laws are either trivial or short-lived and vulnerable to political pressure. Politicians do not violate laws, but the laws are so modified to suit their vested interests. Environment regulations may thus be modified to tap the tourist potential of an area or to set up some other industry. There have been many instances where laws have been changed to accommodate commercialization in hill areas. The Wildlife (Protection) Act, 1972, gives wildlife wardens the power to protect animals in wildlife parks and sanctuaries. But we also find that these wardens exercise their power on traditional entertainers. Monkey, bear and snakes shows on streets are a common scene.

The state earns money by putting wild animals on exhibition in zoological parks and permits circus companies to train animals for entertainment to earn profit. Environmental values are difficult to integrate into Indian law. Though regulatory controls have become stricter, the state of the environment has not improved because of the financial crunch, absence of basic infrastructure, reliance on litigation, absence of comprehensive industrial location policy and absence of relevant technology. In India, several legislations have been passed to check pollution, such as the Air (Prevention of Pollution) Act, Water (Prevention and Control of Pollution) Act, Environment (Protection) Act. The legislation on air has some loopholes since it does not provide for the prevention of interstate air pollution. It deals with the control of noxious emissions from specified industrial processes, automobiles and noise pollution. Smoke and other non-noxious emissions are not covered under this Act. There has to be transparency in the judicial system. The public has the right to know what is going on. The judiciary has to think before passing judgments. Without thinking of alternatives' such as rehabilitation, these verdicts will just continue to push up the cost of illegal management.

**Lecture No: 12**

# Natural and man-made disaster Management

Loss of life and property due to natural disasters like tropical cyclones, floods, droughts, tornadoes, earthquakes, volcanic eruptions etc, is very large. Fortunately warning facilities are available today and by mitigation measures, loss of lives and properties can be minimized. National Meteorological Services of the world to provide warnings to the public for some of the weather related natural disasters. It is not possible to forecast a long period ahead precisely when and where a dangerous natural phenomenon will take place. While natural disasters cannot be prevented, taking proper long-term and short-term disaster mitigation measures can minimize the loss of life and property. Some common disasters known to occur in our country are as under:

**Floods**

Floods are defined as a relatively high flow of water discharged from river and stream network, which sets the riverbank margins to overflow and lead to the inundation of low land areas surrounding the riverbed. It is essentially a physical phenomenon. Floods arise from abnormally heavy rains, dam failures, snow melts, river blockages. Flood disasters rank second only to droughts in the total number of people affected worldwide.

**Types of Floods**

Floods can be classified into three categories as under:

(i) River floods

Rivers get charged due to heavy rains over large catchments areas or by melting of snow or sometimes both especially in the mountainous tracts. The floods take place in river systems with tributaries that may drain into large geographic areas and encompass many independent river basins. Amount of flooding depends on moisture in the soil, vegetation cover, and depth of snow and size of catchments basin.

(ii) Coastal floods

Coastal flooding is associated with tropical cyclones/ harsh winds arising at the ocean surface. Coastal floods are often aggravated by wind induced storm surges along the coastline. Sea and ocean ‘water floods the inland coasts affecting kilometers of tracts. Ocean tides, storm surges or tsunamis play a definite role. Prolonged and indefinite rains in the rainy season marked from June-September results in extreme flood in coastal river basins.

(iii) Flash floods

These floods occur within six' hours of the beginning of rainfall and; are characterized with rising clouds, thunderstorms and tropical cyclones. These result from runoff from a torrential downpour, particularly if the catchments slope is unable to absorb and hold a significant part of water. Other causes of flash floods include dam failure, sudden break up of glaciers etc. These offer potential threats in the areas where the terrain is steep, surface runoff is high, water flows through canyons and where severe rainstorms are likely.

**General Characteristics of Floods**

1. Man-made structures and forest vegetation exhibits different levels of tolerance towards effects of floods.
2. Intensity of damage is governed by the time interval of standing floodwaters.
3. High velocity of running water may uproot or weaken foundations of buildings.
4. Rate of rise and discharge of a river is important as a basis for flood control.
5. Frequency of occurrence estimated over a length of period would determine the kind of activities the flood plain should be put to.
6. Generally the rainy season is characterized by the floods during which agricultural economy suffers a huge loss.

**Effects of Floods**

1. Rising water, erosion and the force damages the residential and commercial building. They are dangerous for villages lying in the coastal areas as it sweeps away everything, which comes into its path. In mountainous areas it is the chief cause
of landslides.
2. Fisherman, local people, cattle, animals and vegetation suffer a great loss of life and property. Most of the deaths are reported to be from drowning.
3. Fresh water supplies by all sources are nearly destroyed and contaminated hence the areas falling under its impact bear a great risk of suffering from water borne diseases.
4. The destruction of food and fodder crops result in acute food shortage.
5. Floods also make soil infertile, as the topsoil is lost due to erosional activity.
6. Floods are also known to preserve, wetlands and recharge ground water.

**Flood Control**

1. Depth and width of the riverbed could be increased as its capacity to carry larger loads increases manifold and thus reduce the area of the flood plain.
2. A network of canals can be established from the river systems, which generally leads to floods. This would also benefit the agricultural economy/ section. Care must be taken in the design and construction because of the possible environmental
impact and necessary safety features.

3. Reservoirs should be made for storing floodwater and releasing them at manageable rates. This would require careful engineering. Dams, and reservoirs would further lead to generation of resources.

4. Newly constructed residential as well commercial buildings should have foundations, which are strong enough to respond to flood conditions.

5. Rivers and streambeds should be stabilized with stone, masonry or vegetation at the banks. This should strictly be followed where rivers pass through cities, specially near bridges.

**Post Disaster Requirements**

The initial response to flooding authorities/community should include:

Search and Rescue operations, water provision, Medical assistance, Disaster epidemiological surveillance assessment, food and and temporary shelter.

The secondary response should include:

Reconstruction of houses, equipment and tools, supply Creation of employment, of animals, and assist with

Assistance to farmers, recovery of small business Distribution of farm and fisheries.

**Flood Problem In India**

The nature of flood problem varies from one river system to another. Two great river systems are discussed below considering the flood problems in India:

Brahmputra River

The main problem of flooding in the northeastern region arises from the Brahmaputra river and its tributaries. The river in monsoon season overflows its banks and causes a great damage to life and property both. Several times it has affected Kaziranga wildlife sanctuary where rhinoceros population died due to rising floods. In recent years, the erosion along the

banks of the Brahmputra has assumed serious proportions. The rivers also carry considerable amount of silt and have a tendency to change its course.

Ganga River System

In this region the northern tributaries of the Ganga, namely the Rapti, the Sharada, the Ghaghra and the Gandak cause extensive flooding along their banks. Drainage congestion is confined to the northwestern parts of U.P., Meerut, Mathura and Agra suffers the most. Bihar suffers a considerable amount of damage due to the flooding of the Burhi Gandak, the

Baghirati, the Kamla Balan, the Kosi and the Mahananda. In addition to the crop submergence the area experiences traffic dislocation also. In the Bengal region Baghirati, the Ajoy and the Damodar cause extensive flooding. Here the tidal effect of Bay of Bengal also plays a role in flooding. In Delhi and Haryana it is the Yamuna, the biggest tributary of the Ganga,

which causes a marginal amount of flooding. Most of these flooding regions suffer from inadequate channel capacity as well as regulation of river water flow in these channels.

**Earthquakes and Seismology**

An earthquake is a major demonstration of the power of the tectonic forces caused by endogenetic thermal conditions of the interior of the earth. An earthquake is a motion of the ground surface, ranging from a faint tremor to a wild motion capable of shaking buildings apart and causing gaping fissures to open in the ground. The Richter scale devised by

Charles F. Richter in 1935 measures the magnitude or intensity of energy released by an earthquake. Good Friday Earthquake of March 27, 1964 in Alaska (USA) measuring 8.4 to 8.6 on Richter scale is among the greatest earthquakes of the world ever recorded. The science that studies the behaviour and patterns of seismic waves is called seismology.

The place of origin of an earthquake is called focus, which is always hidden inside the earth, but its depth varies from place to place. The place of the origin of an earthquake is called 'focus' which is always hidden inside the earth. The deepest earthquake may have its focus at a depth of even 700 km below the ground surface. Major Himalayan earthquakes, such

as the Bihar-Nepal earth quake of August 2, 1988, have their focus around 20-30 km deep.

The place on the ground surface, which is perpendicular to the buried 'focus' or 'hypocenter', recording the seismic waves for the first time is called 'epicenter'. The waves generated by an earthquake are called 'seismic waves' which are recorded by an instrument called seismograph. The lines joining the places of equal intensity of seismic waves on the maps

are called is oseismallines.

**Causes of Earthquakes**

Earthquakes are caused mainly due to disequilibria in any part of the crust of the earth. A number of causes have been assigned to cause disequilibria in the earth's crust such as volcanic eruptions, faulting and folding, gaseous expansion and contraction inside the earth, hydrostatic pressure of man-made water bodies like reservoirs and lakes, and plate

movements.

(1) Vulcan City

Volcanic activity is considered to be one of the major causes of earthquakes. Vulcan city and seismic events are so intimately related to each other that they become cause and effect for each other. Earthquakes follow each volcanic eruption and many of the severe earthquakes cause volcanic eruptions. The explosive violent gases during the process of Vulcan city try to escape upward and hence they push the crystal surface from below with great force and

thus is' caused severe earth tremors of high magnitude.

(2) Faulting and Elastic Rebound Theory

The horizontal and vertical movements caused by end genetic forces result in the formation of faults and folds which in turn cause isocratic disequilibria in the crystal rocks which ultimately causes earthquakes of varying magnitudes depending on the nature and magnitude of dislocation of rock blocks caused by faulting and folding. The 1950 earthquake
of Assam was believed to have been caused due to disequilibria in crystal rocks;

(3) Hydrostatic Pressure and Anthropogenic Causes

Certain human activities such as pumping of ground water and oil, deep underground mining, blasting of rocks by dynamites for constructional purposes, nuclear explosion, storage of huge volume of water in big reservoirs etc. also cause earth tremors of serious consequences. The introduction of additional load through the construction of large dams and impounding of enormous volume of water in big reservoirs behind the dams cause disequilibria of adjusted
rocks below the reservoirs.

(4) Plate Tectonic Theory

The earth is composed of solid and moving plates having either continental crust or oceanic crust or even both continental oceanic crusts. The earth's crust consists of 6 major plates (Eurasian plate, American plate, African plate, Indian plate, Pacific plate and Antarctic plate) and 20 minor plates. These plates are constantly moving in relation to each other due
to thermal convective currents originating deep within the earth. All sorts of disequilibria are caused due to different types of plate motions and consequently earthquakes of varying magnitudes are caused.

**Effects of Earthquake hazardous**

Earthquakes and their hazards are determined on the basis of the magnitude of seismic intensity as determined by Richter scale but are decided in the basis of quantum of damages done by a specific earthquake to human lives and property.

(i) Landslides

Weaker landmasses and tectonically sensitive land margins cause landslides and debris falls, which damage settlements and transport systems on the lower slope segments.

(ii) Damage to Life and property

Structures such as buildings, roads, rails, factories, dams, bridges suffer a huge damage thus causing a heavy loss of human life and property both. The vibrations of earthquakes last longer and the amplitudes of seismic waves are greater artificially in filled and levelled depressions, swamp deposits etc. than in the structures of consolidated materials and bedrocks.

Two major earthquakes of Bihar-Nepal border in 1934 and 1988 explain the impact of earthquake disasters on human structures and human lives. The damage caused by the Bihar

earthquake of 15 January 1934, measuring 8.4 on Richter scale, include 10,700 human deaths, landslides and slumping in an area of 250 km length and 60 km width, ruptures and faults in the ground surface etc.

(iii) Damages to Government Infrastructure

Cities and towns are worst affected due to large concentration of human population, commercial complexes and residential areas. Due to collapse of large buildings there is greater loss of life and property. Due to collapse of buildings ground water pipes are bent and damaged thus water supply is disrupted, electric and telephone poles are uprooted and there is total disruption of power and communication. Other side effects are collapsed sewer system causing epidemics, roadblocks etc.

(iv) Fire Hazard

Earthquakes strongly shake the buildings and thus strong oscillations cause severe fires in houses, mines and factories because of overturning of cooking gas cylinders, contact of live electric wires, churning of blast furnaces, displacement of other electric and firerelated appliances.

(v) Landmass Deformation

Severe earth tremors and resultant, vibrations caused by severe earthquakes result in the deformation of ground surface because of crusts and troughs in the ground surface and faulting activity.

(vi) Flash Floods

Strong seismic events result in the damages of dams and cause severe flash floods. Severe floods are also caused because of blocking of water flow of rivers due to rock blocks and debris produced by severe tremors on the hill slopes facing the river valleys.

(vii) Tsunamis

The seismic waves, caused by the earthquakes traveling through seawater, generate high sea waves and cause great loss of life and property. Since the pacific Ocean is girdled by the earthquakes and volcanoes tsunamis are more common in the pacific with a minimum frequency of 2 tsunamis per year.

**Cyclones**

Cyclones are the centers of low pressure surrounded by closed isobars having increasing pressure outward and closed air circulation from outside towards the central low pressure in such a way that air blows inward in anticlockwise on northern hemisphere and clockwise in southern hemisphere. They range in shape from circular, elliptical to V shape. From

locational viewpoint cyclones are classified into two principal types e.g. i) extra-tropical cyclones/temperate cyclones ii) tropical cyclones.

**(I) Temperate Cyclones**

Temperate cyclones are atmospheric disturbances having low pressure in the centers produced in the middle latitudes characterized by converging and rising air, cloudiness and precipitation. They are formed in the regions extending between 350- 65" latitudes in both hemispheres due to convergence of two contrasting air masses e.g. After their formation

temperate cyclones move in easterly direction under the influence of westerly winds and control the weather conditions in the middle latitudes.

(i) Shape, Size and Speed

Temperate cyclones are of different shapes e.g. circular, semi-circular, elliptical, elongated or V, but all of them are characterized by low pressure in their centres and closed isobars. The pressure difference between the centre and periphery is about 10-35 mb. It means that pressure increases from the centre towards outer margin. Average large diameter of an

ideal cyclone is about t 900 km while short diameter measures t 000 km. The temperate cyclones move eastward under the influence of westerly winds with average velocity of 32 km per hour in summer and 48 km per hour in winters.

(ii) Wind Systems

Since there is low pressure in the centre of temperate cyclone and air pressure increases outward and hence winds blow from the periphery towards the centre but these winds do not reach the centre straight rather they cut the isobars at the angle of 20° to 400 due to friction and Coriolis force and thus wind direction becomes anticlockwise in the northern

hemisphere and clockwise in the southern hemisphere. Since temperate cyclones are formed due to convergence of two contrasting air masses and hence it is natural that there are variations in the nature and direction of winds in different parts of the cyclones.

(iii) Temperature

Different temperatures are noted in different parts of temperate cyclones because of their origin due to convergence of two thermally contrasting air masses. The southern part of cyclone records higher temperature because of the dominance of warm air while the north-eastern, northern and north-western parts record low temperature because of the dominance of cold polar air mass. The western part records lowest temperature.

(iv) Source Regions and Tracks of Movement

The areas frequented by temperate cyclones mostly lie in the middle and high latitudes extending between 350-650 latitudes in both the hemispheres. These cyclones move, on an average, in

easterly direction. (1) Cyclones after originating in the north Pacific off the north-east and eastern coasts of Asia move in easterly and north-easterly direction towards
the Gulf of Alaska and ultimately merge with Aleutian Lows from where they follow southerly direction and reach as far south as southern California. The cyclones moving inland dissipate and are occluded at the windward western slopes of the Rocky Mountains.

(v) Origin of Temperate Cyclones

Though the formation and development of temperate cyclones is a quick process but it passes through a series of successive stages. The period of a cyclone from its inception (cyclogenesis) to its termination (proteolysis or occlusion) is called the 'life cycle of cyclone';which is completed through six successive stages.

(*a*) **The first stage** involves the convergence of two air masses of contrasting physical properties and directions. Initially, the air mass (warm and cold) move parallel to each other and a stationary front is formed. This is called initial stage.

(*b*) **The second stage** is also called as 'incipient stage', during which the warm and cold air masses penetrate into the territories of each other and thus a wave-like front is formed.

(*c*) **Third stage:** This is the mature stage when the cyclone is fully developed and isobars become almost circular.

(*d*) **Fourth stage:** Warm sector is narrowed in extent due to the advancement of cold front than warm front, as cold front comes nearer to warm front.

(*e*) **Fifth stage:** Starts with the occlusion of cyclone when the advancing cold front finally overtakes the warm front and an occluded front is formed.

(*f*) **Sixth stage:** Warm sector completely disappears, occluded front is eliminated and ultimately cyclone dies' out.

**(II) Tropical Cyclones**

(i) General Characteristics

Cyclones developed in the regions lying between the tropics of Capricorn and Cancer are called Tropical Cyclones which are not regular and uniform like extra tropical or temperate cyclones. There are numerous forms of these cyclones, which vary considerably in shape, size, velocity and weather conditions. The weather conditions of low latitudes mainly rainfall
regimes are largely controlled by Tropical Cyclones.

(*a*) Size of tropical cyclones varies considerably. On an average their diameters range between 80 km and 300 km.

(*b*) Weak cyclones move at the speed of about 32 km per hour while hurricanes attain the velocity of 180 km per hour or more.

(*c*) Tropical cyclones become more vigorous over the oceans but become weak and feeble while moving over land areas. This is why these cyclones affect only the coastal areas e.g. Tamil Nadu, Orissa and West Bengal coasts of India.

(*d*) The centre of the cyclone is characterized by extremely low pressure.

(*e*) Tropical cyclones are not characterized by temperature variations in their different parts because they do not have different fronts.

(*f*) There are no different rainfall cells hence each part of the cyclones yields rainfall.

(*g*) Tropical cyclones are not always mobile. Normally, they move from east to west under the influence of trade winds

(*h*) Tropical cyclones are confined to a particular period of the year (summer season).

(ii) Types of Tropical Cyclones

Generally they are divided into 4 major types:

(*a*) Tropical disturbances or easterly waves

(*b*) Tropical depressions

(*c*) Tropical storms

(*d*) Hurricanes or typhoons

(iii) Origin of Tropical Cyclones

On an average, tropical cyclones are formed due to development of low pressure of thermal origin. They develop when the following requirements are fulfilled:

(*a*) There should be continuous supply of abundant warm and moist air. Tropical cyclones originate over warm oceans having surface temperature of 27°C.

(*b*) Higher value of Coriolis force is required for the origin of these cyclones.

(*c*) They are associated with inter-tropical convergence (lTC), which extends from 50 -300N latitudes during summer season.

(*d*) There should be anti-cyclonic circulation at the height of 9000 to 15000 m above the surface disturbance.

(iv) Distribution of Tropical Cyclones

There are 6 major regions of the tropical cyclones e.g. (1) West Indies, Gulf of Mexico, and Caribbean Sea. (2) Western North Pacific Ocean including Philippines, Islands, China Sea, and Japanese Islands. (3) Arabian Sea and Bay of Bengal. (4) Eastern Pacific coastal region off Mexico and Central America. (5) South Indian Ocean of Madagascar (Malagasi),

and (6) Western South Pacific Ocean, in the region of Samoa and Fiji Island and the east and north coasts of Australia.

(v) Environmental Impact of Tropical Cyclones

Tropical cyclones are very severe disastrous natural hazards which inflict heavy loss to human lives and property in terms of destruction of buildings, transport systems, water and power supply systems, disruption of communication system, destruction of standing agricultural crops, domestic and wild animals, natural vegetation, private and public institutions etc. Through damages caused by high velocity winds, floods and storm surges.

**ANTICYCLONES**

**General Characteristics**

Surrounded by circular isobars anticyclone is such a wind system which has highest air pressure at the centre and lowest at the outer margin and winds blow from the centre outward in clockwise direction in the northern hemisphere and anticlockwise in the southern hemisphere fig.13. Thus, anticyclones are high-pressure systems and more common in the subtropical high pressure belts but are practically absent in the equatorial regions.

Anticyclones were classified into (*i*) **warm anticyclones**, and (*ii*) **cold anticyclones** by Hanzilk in 1909.

They are characterized by the following properties.

(1) They are usually circular in shape. The difference of pressure between the centre and periphery of anticyclone ranges between 10-20 mb.

(2) They are much larger in size and area than temperate cyclones.

(3) Anticyclones follow cyclones. They move very sluggishly. The average velocity of anticyclones is 30-50 km per hour.

(4) Winds descend from above at the centre and thus weather becomes clear and rain less because the descending winds cause atmospheric stability.

(5) Temperature in anticyclones depends on weather, nature of air mass and humidity in the air.

(6) Anticyclones do not have fronts.

1. Wind Systems and Temperature

Wind system is not fully developed in anticyclones because of weak pressure gradient. On an average, wind circulation is of divergent system wherein winds spread in all directions from high-pressure centre to low-pressure periphery. The winds are very much sluggish in the rear portion in comparison to the front portion. The centre is characterized by light breeze. These arise due to the descent of either polar cold air mass or warm tropical air mass. Cold anticyclones are associated with extremely low temperature and they cause cold waves during winter season but when they come in summer season, weather becomes pleasant.

2. Shapes and Size

Anticyclones are generally of circular shape but are very large in size. They become so large in size that their diameters become 9,000 km.

3. Weather Conditions

Generally, anticyclones are rainless and sky is free of clouds because of the fact that descending air in the centre of anticyclone is warmed up at dry adiabatic rate due to subsidence. This causes rise in temperature, which reduces normal lapse rate of temperature, with the result the stability of air increases resulting into marked increase in the aridity of
air. This is why anticyclones are indicative of dry weather.

4. **Landslides**

Among physiographic units, the two northern units of the Greater Himalayas (7500- 8500m), and the Inner Himalayas (Trans-Himalayan zone), an intervening system of high plateau and valleys lying between the two great mountain ranges, are considered along with middle mountains, the traditional centres of population. The upper northern section of these
middle mountains remains largely' under upper montane forest (2900-4000 m), below which is the belt of intensive agriculture. Lithology is highly varied, including sedimentary, metamorphism, and granites. However, there are extensive areas of phyllites and schists; these are deeply weathered and the prevailing steep slopes render them highly susceptible
to erosion and slope failure (mostly through landslides). Presently, according to gross yet reliable estimate, the landslides occupy about 1% of land surface in only five central districts of Himachal Pradesh. They have a total volume of more than 2.2 x 106 m3 and a mean age of 6.5 years. This helps to evaluate the denudation rate, which is about 12 mm/year (all
erosive processes). Landslides have about 2.5-mm/ year denudation rates. One of the main causes of landslides is road construction.

## Lecture No: 13

### Climate change, global warming Acid rain, Ozone layer depletion

**Climate change**:

The average temperature in many regions has been increasing in recent decades. The global average surface temperature has increased by 0.6° + 0.2° C over the last century. Globally, 1998 was the warmest year and the 1990s the warmest decade on record. Many countries have experienced increases in rainfall, particularly in the countries situated in the mid to high atitudes.

In some regions, such as parts of Asia and Africa, the frequency and intensity of droughts have been observed to increase in recent decades. Episodes of El Niño, which creates great storms, have been more frequent, persistent and intense since mid-1970s compared with the previous 100 years. All these are signs that the earth is sick. Its climate is changing, making it more difficult for mankind to survive. The earth is losing its ability to balance itself due to the imbalances created by human activities.

Projections of future climate change are derived from a series of experiments made by computer based global climate models. These are worked out on estimates of aspects such as future population growth and energy use. Climatologists of the Intergovernmental Panel on Climate Change (IPCC) have reviewed the results of several experiments in order to estimate changes in climate in the course of this century. These studies have shown that in the near future, the global mean surface temperature will rise by 1.4° to 5.8°C. Warming will be greatest over land areas, and at high latitudes. The projected rate of warming is greater than has occurred in the last 10,000 years. The frequency of weather extremes is likely to increase leading to floods or drought. There will be fewer cold spells but more heat waves. The frequency and intensity of El Niño is likely to increase. Global mean sea level is projected to rise by 9 to 88 cm by the year 2100. More than half of the world's population now lives within 60km of the sea. They are likely to be seriously impacted by an ingress of salt water and by the rising sea. Some of the most vulnerable regions are the Nile delta in Egypt, the Ganges-Brahmaputra delta in Bangladesh, and many small islands including the Marshall Islands and the Maldives, (WHO, 2001).

Human societies will be seriously affected by extremes of climate such as droughts and floods. A changing climate would bring about changes in the frequency and/or intensity of these extremes. This is a major concern for human health. To a large extent, public health depends on safe drinking water, sufficient food, secure shelter, and good social conditions. All these factors are affected by climate change. Fresh water supplies may be seriously affected, reducing the availability of clean water for drinking and washing during drought as well as floods. Water can

be contaminated and sewage systems may be damaged. The risk of spread of infectious diseases such as diarrhoeal diseases will increase. Food production will be seriously reduced in vulnerable regions directly and also indirectly through an increase in pests and plant or animal diseases. The local reduction in food production would lead to starvation and malnutrition with long-term health consequences, especially for children. Food and water shortages may lead to conflicts in vulnerable regions, with serious implications for public health. Climate change related impacts on human health could lead to displacement of a large number of people, creating environmental refugees and lead to further health issues.

**Global warming**:

About 75% of the solar energy reaching the Earth is absorbed on the earth's surface which increases its temperature. The rest of the heat radiates back to the atmosphere. Some of the heat is trapped by greenhouse gases, mostly carbon dioxide. As carbon dioxide is released by various human activities, it is rapidly increasing. This is causing global warming. The average surface temperature is about 15°C. This is about 33°C higher than it would be in the absence of the greenhouse effect. Without such gases most of the Earth's surface would be frozen with a mean air temperature of -18°C. Human activities during the last few decades of industrialisation and population growth have polluted the atmosphere to the extent that it has begun to seriously affect the climate. Carbon dioxide in the atmosphere has increased by 31% since pre-industrial times, causing more heat to be trapped in the lower atmosphere. There is evidence to show that carbon dioxide levels are still increasing. Many countries have signed a convention to reduce greenhouse gases under the United Nations Convention on Climate Change. Current international agreements are however not still effective to prevent the significant changes in climate and a rise in sea levels.

**Acid rain**:

When fossil fuels such as coal, oil and natural gas are burned, chemicals like sulfur dioxide and nitrogen oxides are produced. These chemicals react with water and other chemicals in the air to form sulfuric acid, nitric acid and other harmful pollutants like sulfates and nitrates. These acid pollutants spread upwards into the atmosphere, and are carried by air currents, to finally return to the ground in the form of acid rain, fog or snow. The corrosive nature of acid rain causes many forms of environmental damage. Acid pollutants also occur as dry particles and gases, which when washed from the ground by rain, add to the acids in the rain to form a more corrosive solution. This is called acid deposition.

Damage from acid rain is widespread in North America, Europe, Japan, China and Southeast Asia. In the US coal burning power plants contribute to about 70% of sulfur dioxide. In Canada oil refining, metal smelting and other industrial activities account for 61% of sulphur dioxide pollution. Motor vehicle exhaust fumes are the main source of nitrogen oxides. The acids in acid rain chemically react with any object they come in contact with. Acids react with other chemicals by giving up hydrogen atoms. Effects: Acid rain is known to cause widespread environmental damage.

1. Acid rain dissolves and washes away nutrients in the soil which are needed by plants. It can also dissolve naturally occurring toxic substances like aluminium and mercury, freeing them to pollute water or poison plants.
2. Acid rain indirectly affects plants by removing nutrients from the soil in which they grow. It affects trees more directly by creating holes in the waxy coating of leaves, causing brown dead spots which affect the plant's photosynthesis. Such trees are also more vulnerable to insect infestations, drought and cold. Spruce and fir forests at higher elevations seem to be most at risk. Farm crops are less affected by acid rain than forests.
3. Acid rain that falls or flows as ground water to reach rivers, lakes and wetlands, causes the water in them to become acidic. This affects plant and animal life in aquatic ecosystems.
4. Acid rain also has far reaching effects on wildlife. By adversely affecting one species, the entire food chain is disrupted, ultimately endangering the entire ecosystem. Different aquatic species can tolerate different levels of acidity. For instance clams and mayflies have a high mortality when water has a pH of 6.0, while frogs can tolerate more acidic water, although with the decline in supply of mayflies, frog populations may also decline.

**Solutions**:

The best way to stop the formation of acid rain is to reduce the emissions of sulphur dioxide and nitrogen oxides into the atmosphere. This can be achieved by using less energy from fossil fuels in power plants, vehicles and industry. Switching to cleaner burning fuels is also a way out. For instance using natural gas which is cleaner than coal, using coal with lower sulfur content, and developing more efficient vehicles. If the pollutants have already been formed by burning fossil fuels, they can be prevented from entering the atmosphere by using scrubbers in smokestacks in industry. These spray a mixture of water and limestone into the polluting gases, recapturing the sulfur. In catalytic converters, the gases are passed over metal coated beads that convert harmful chemicals into less harmful ones. These are used in cars to reduce the effects of exhaust fumes on the atmosphere. Once acid rain has affected soil, powdered limestone can be added to the soil by a process known as liming to neutralize the acidity of the soil.

**Ozone layer depletion**:

Ozone is formed by the action of sunlight on oxygen. It forms a layer 20 to 50kms above the surface of the earth. This action takes place naturally in the atmosphere, but is very slow. Ozone is a highly poisonous gas with a strong odour. It is a form of oxygen that has three atoms in each molecule. It is considered a pollutant at ground level and constitutes a health hazard by causing respiratory ailments like asthma and bronchitis. It also causes harm to vegetation and leads to a deterioration of certain materials like plastic and rubber. Ozone in the upper atmosphere however, is vital to all life as it protects the earth from the sun's harmful ultraviolet radiation. The ozone layer in the upper atmosphere absorbs the sun's ultraviolet radiation, preventing it from reaching the earth's surface. This layer in the atmosphere protects life on earth from the dangerous UV radiation from the sun. In the 1970s, scientists discovered that chemicals called chlorofluorocarbons or CFCs, which were used as refrigerants and aerosol spray propellants, posed a threat to the ozone layer. The CFC molecules are virtually indestructible until they reach the stratosphere, where UV radiation breaks them down to release chlorine atoms. The chlorine atoms react with ozone molecules which break down into oxygen molecules, which do not absorb UV radiations. Since the early 1980s, scientists detected a thinning of the ozone layer in the atmosphere above Antarctica. This phenomenon is now being detected in other places as well including Australia. Although the use of CFCs has been reduced and now banned in most countries, other chemicals and industrial compounds such as bromine, halocarbons and nitrous oxides from fertilizers may also attack the ozone layer.

The destruction of the ozone layer is seen to cause increased cases of skin cancer and cataracts. It also causes damage to certain crops and to plankton, thus affecting natures food chains and food webs. This in turn causes an increase in carbon dioxide due to the decrease in vegetation. With the signing of the Montreal Protocol in 1987, a treaty for the protection of the ozone layer, the use of CFCs was to be banned by the year 2000. After 2000, the ozone layer is expected to recover slowly over a period of about 50 years.

**Lecture No: 14**

## Disaster management

DISASTER MANAGEMENT: FLOODS, EARTHQUAKES, CYCLONES, LANDSLIDES

The Indian subcontinent is very vulnerable to droughts, floods, cyclones, earthquakes, landslides, avalanches and forest fires. Among the 36 states and Union territories in the country, 22 are prone to disasters. Among all the disasters that occur in the country, floods are the most frequently occurring natural disasters, due to the irregularities of theIndian monsoon. About 75 percent of the annual rainfall in India is concentrated in three to four months of the monsoon season. As a result there is a very heavy discharge from the rivers during this period causing widespread floods. Approximately 40 million hectares of land in the country has been identified as being prone to floods. Major floods are mainly caused in the Ganga-Brahmaputra-Meghna basin which carries 60 percent of the total river flow of our country.

India has a long coastline of 5700 kms, which isexposed to tropical cyclones arising in the Bay of Bengal and the Arabian sea. The Indian Ocean is one of the six major cyclone prone regions of the world. In India, cyclones occur usually between April and May and also between October and December. The eastern coastline is more prone to cyclones as it is hit by about 80 percent of the total cyclones generated in the region. Droughts are a perennial feature in some states of India. Sixteen percent of the country's total area is drought prone. Drought is a significant environmental problem as it is caused by a lower than average rainfall over a long period of time.

Most of the drought prone areas identified by the Government lie in the arid and semi-aridareas of the country. Earthquakes are considered to be one of the most destructive natural hazards. The impact of this phenomenon occurs with so little warning that it is almost impossible to make preparations against damages and collapse of buildings. About 50 to 60 percent of India is vulnerable to seismic activity of varying intensities. Most of the vulnerable areas are located in the Himalayan and sub-Himalayan regions. From management to mitigation of disasters Till very recently the approach towards dealing with natural disasters has been post disaster management involving problems such as evacuation, warnings, communications, search and rescue, fire-fighting, medical and psychiatric assistance, provision of relief, shelter, etc. After the initial trauma and the occurrence of the natural disaster is over and reconstruction and rehabilitation is done by people, NGOs and the Government, its memories are relegated to history.

It is evident today that human activities are responsible for accelerating the frequency and severity of natural disasters. Natural occurrences such as floods, earthquakes, cyclones, etc. will always occur. They are a part of the environment that we live in. However destruction from natural hazards can be minimized by the presence of a well functioning warning system

combined with preparedness on part of the community that will be affected. Thus though traditionally disaster management consisted primarily of reactive mechanisms, the past few years have witnessed a gradual shift towards a more proactive, mitigation based approach.

Disaster management is a multidisciplinary area in which a wide range of issues that range from forecasting, warning, evacuation, search and rescue, relief, reconstruction and rehabilitation are included. It is also multi-sectoral as it involves administrators, scientists, planners, volunteers and communities. These roles and activities span the pre-disaster, during disaster and post disaster plans. Since their activities are complementary as well as supplementary to each other there is a critical need for coordinating these activities. In order to transfer the benefits of scientific research and development to the communities links must be developed between scientific communities and field agencies. Coordination between Government agencies and NGOs needs to be built up so that overlap of activities may be avoided and linkages between the Government and communities are established.

Today we have a range of early warning systems for a range of natural hazards. Although they are more accurate than before and can helpin prediction it is not enough to ensure communitiesare safe from disasters. This is where disaster mitigation can play an important role. Mitigation means lessening the negative impact of the natural hazards. It is defined as sustained action taken to reduce long term vulnerability of human life and property to natural hazards. While the preparatory, response and the recovery phases of emergency management relate to specific events, mitigation activities have the potential to produce repetitive benefits over time.

Certain guidelines if followed can result in an effective mitigation program.

• Pre-disaster mitigation can help in ensuring faster recovery from the impacts of disasters.

• Mitigation measures must ensure protection of the natural and cultural assets of the community.

• Hazard reduction methods must take into account the various hazards faced by the affected community and their desires and priorities.

• Any mitigation program must also ensure effective partnership between Government, scientific, private sector, NGOs and the community.

The main elements of a mitigation strategy are as follows: Risk assessment and Vulnerability analysis. This involves identification of hot spot areas of prime concern, collection of information on past natural hazards, information of the natural ecosystems and information on the population and infrastructure. Once this information is collected a risk assessment should be done to determine the frequency, intensity, impact and the time taken to return to normalcy after the disaster. The assessment of risk and vulnerabilities will need to be revised periodically. A

regular mechanism will therefore have to be established for this. The use of Geographical Information Systems (GIS) a computer program can be a valuable tool in this process as the primary data can be easily updated and the corresponding assessments can be made.

Applied research and technology transfer: There is a need to establish or upgrade observation equipment and networks, monitor the hazards properly, improve the quality of forecasting and warning, disseminate information quickly through the warning systems and undertake disaster simulation exercises. Thus space technologies such as remote sensing, satellite communications and Global Positioning Systems have a very important role to play. Government organizations like ISRO (Indian Space Research Organization) can play a vital role. Similarly Government organizations the National Building Research Organization, the Meteorological Department, Irrigation Department, etc. can undertake applied research for devising locale specific mitigation strategies in collaboration with educational institutions or Universities.

Such steps could lead to the formulation of local especific mitigation measures. A combination of scientific knowledge and expertise with the community based mitigation measures would not only enhance the database but would also form the basis of a successful mitigation strategy.

Public awareness and training: One of the most critical components of a mitigation strategy is the training to be imparted to the officials and staff of the various departments involved at the state and the district level. This enables sharing of information and methodology. The success of a mitigation strategy will depend to a large extent on the inter-sectional, inter-departmental coordination and efficient teamwork. Thus a training program that is designed after assessment of gaps in knowledge, skills and attitude with respect to the various tasks that need to be undertaken is a vital component. Institutional mechanisms The most important need at the National level is to strengthen or develop the capacity to undertake disaster mitigation strategies. There is a need to emphasize on proactive and pre-disaster measures rather than post disaster response. It is thus essential to have a permanent administrative structure which can monitor the developmental activities across departments and provides suggestions for necessary mitigation measures. The National Disaster Management Center (NDMC) can perform such a task. Professionals like architects, structural engineers, doctors, chemical engineers who are involved with management of hazardous chemicals can be asked to form groups that can design specific mitigation measures.

Incentives and resources for mitigation: To a very large extent the success of mitigation programs will depend upon the availability of continued funding. There is thus a need to develop mechanisms to provide stable sources of funding for all mitigation programs. This will include

incentives for relocation of commercial and residential activities outside the disaster prone areas. Housing finance companies should make it mandatory for structures in such hazard prone areas to follow special building specifications. The introduction of disaster linked insurance should be explored and should cover not only life but also household goods, cattle, structures and crops.

Land use planning and regulations: Long term disaster reduction efforts should aim at promoting appropriate land-use in the disaster prone areas. Separation of industrial areas from residential areas, maintaining wetlands as buffer zones for floods, creation of public awareness of proper land practices and formation of land-use policies for long term sustainable development is imperative.

Hazard resistant design and construction: In areas that are prone to disasters protection can be enhanced by careful selection of sites and the way the buildings are built. Thus it is essential to promote the knowledge of disaster resistant construction techniques and practices among engineers, architects and technical personnel. Structural and Constructional reinforcement of existing buildings It is also possible to reduce the vulnerability of existing buildings through minor adaptations or alterations thereby ensuring their safety. This can be done by insertion of walls on the outside of the building, buttresses, walls in the interior of the building, portico fill-in-walls, specially an chored frames, covering of columns and beams, construction of new frame system, placing residential electrical equipment above flood level, designing water storage tanks to be able to withstand cyclonic winds, earthquakes and floods, etc.

Earthquakes and mitigation measures: It has been several years since the earthquake struck Gujarat on January 26, 2001. In these years rehabilitation has been done on a massive scale. Gujarat's experience has taught that building shelters with less vulnerability to earthquakes should also take into consideration the specific needs of the victims instead of being a top down approach. The role of NGOs in this is very important. Their strength lies in their manpower, informality in operations and valuable human resources. Their ability to reach out to the community and sensitivity to local traditions is an asset in such situations. A report on the various initiatives in Gujarat reported in Down to Earth (Vol 12, No. 2) by Mihir Bhatt throws light on the various developments that have taken place after the earthquake. According to the report the initiatives of the International Fund for Agriculture Development in supporting the Self Employed Women's Association and the Government's initiative in community based livelihood security for earthquakes and drought victims have the potential to shape future disaster response and development projects in Gujarat.

Similarly the Gujarat Woman's Economic Development Corporation initiative in reviving women's businesses after the calamity also provides many practical lessons in regenerating local economies and artisan markets. This project supported by the Asian

Development Bank, puts premium on investments in income generation and asset building after a natural disaster. The farming kits provided to affected farmers by Gujarat's agriculture ministry is also showing promising results after two seasons. The author however states that coordination between Government, local NGOs and local community initiatives both for rescue as well as rehabilitation needs to be strengthened as this can cause delays, overlaps and waste of relief material and efforts.

Cyclones and mitigation measures: Tropical cyclones are the worst natural hazards in the tropics. They are large revolving vortices in the atmosphere extending horizontally from 150 to1000 km and vertically from the surface to 12 to 14 km. These are intense low-pressure areas. Strong winds spiraling anti clockwise in the Northern Hemisphere blow around the cyclone center at the lower level. At the higher levels the sense of rotation is just opposite to that at the lower level. They generally move 300 to 5000 km per day over the ocean. While moving over the ocean they pick up energy from the warm water of the ocean and some of them grow into a devastating intensity. On an average about 5 to 6 tropical cyclones form in the Bay of Bengal and the Arabian Sea every year out of which 2 to 3 may be severe. More cyclones form in the Bay of Bengal than in the Arabian Sea. The main dangers from cyclones are very strong winds, torrential rains and high storm tides. Most of the causalities are caused by coastal inundation by storm tides. This is often followed by heavy rainfall and floods. Storm surges cause the greatest destruction. Although one cannot control cyclones, the effects of cyclones can be mitigated through effective and efficient mitigation policies and strategies. A brief description of the same is given below.

Installation of early warning systems: Such systems fitted along the coastlines can greatly assist forecasting techniques thus helping in early evacuation of people in the storm surge areas. Developing communication infrastructure: Communication plays a vital role in cyclone disaster mitigation and yet this is one of the first services that gets disrupted during cyclones. Amateur Radio has today emerged as second line unconventional communications systems and is an important tool for disaster mitigation. Developing shelter belts: Shelter belts with plantations of trees can act as effective wind and tide breakers. Apart from acting as effective windbreakers and protecting soil crops from being damaged they prevent soil erosion.

Developing community cyclone shelters: Cyclone shelters at strategic locations can help minimizing the loss of human life. In the normal course these shelters can be used as public utility buildings. Construction of permanent houses: There is a need to build appropriately designed concrete houses that can withstand high winds and tidal waves. Training and education: Public awareness programs that inform the population about their response to cyclone warnings and preparedness can go a long way in reducing causalities.

Landslides and mitigation measures: Landslides are recurring phenomena in the Himalayan region. In the recent years however intensive construction activity and the destabilizing forces of nature have aggravated the problem. Landslides occur as a result of changes on a slope, sudden or gradual, either in its composition, structure, hydrology or vegetation. The changes can be due to geology, climate, weathering, land-use and earthquakes.

A significant reduction in the hazards caused by landslides can be achieved by preventing the exposure of population and facilities to landslides and by physically controlling the landslides. Developmental programs that involve modification of the topography, exploitation of natural resources and change in the balance load on the ground should not be permitted. Some critical measures that could be undertaken to prevent further landslides are drainage measures, erosion control measures such a bamboo check dams, terracing, jute and coir netting and rockfall control measures such as grass plantation, vegetated dry masonry wall, retaining wall and most importantly preventing deforestation and improving afforestation.

Disasters cannot be totally prevented. However early warning systems, careful planning and preparedness on part of the vulnerable community would help in minimizing the loss of life and property due to these disasters.

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